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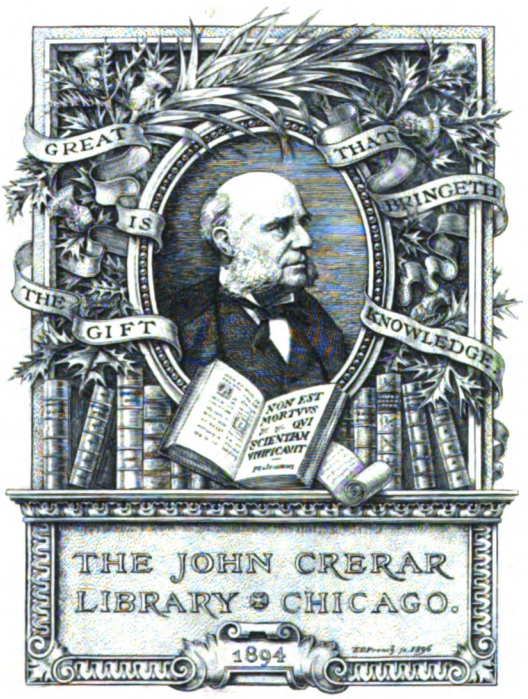

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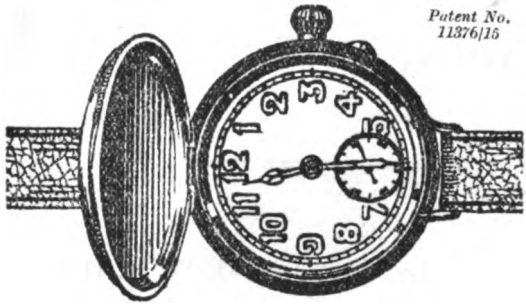

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BATTLES, ANCIENT AND MODERN.

By Lieut.-Colonel H. W. L. Hime.

ABOUT fifty years ago Mr. Robert Lowe (afterwards Lord Sherbrooke) declared publicly at the Institute of Civil Engineers that the battle of Marathon was of less importance than "a good colliery accident". As Mr. Lowe was an accomplished scholar, his words may not have been quite serious; but whether made in jest or earnest his statement called down a shower of protests, by which it was supposed that this fiction was extinguished. But fictions have a miraculous vitality, and this same fiction has lately reappeared among us, though in a more comprehensive and aggressive form. When someone last year mentioned a battle fought about a century ago, some military man who was present remarked that such battles were hardly worth notice. "The armies engaged," he said, and the losses incurred were quite insignificant when compared with those of the present day, and these old-fashioned combats may well be ignored." Two fallacies, it seems to me, lie at the bottom of this statement; first, that nothing is to be learnt from battles of the past, fought with bygone arms on obsolete principles of tactics; and secondly, that great effects can be only gained by battles which are fought by great armies and with great loss.

On the first fallacy Major Robert Hume, R.E. remarked:—"it is quite true that the introduction of improved arms has produced very considerable modifications in the method of fighting; but these modifications are not so much changes, as the growth and development of principles that have been known for hundreds of years. And it is a most dangerous thing to ignore all experience obtained prior to the introduction of improved arms, for it is only by a careful study of the development of tactics that the true direction in which improvement is possible can be determined."[1]

This is perfectly true. An officer who has studied the tactics of a period has acquired some useful knowledge, but let him not imagine that this is the "be all and end all" of tactics. No one can be said to have mastered the subject until he has surveyed the tactics of all periods, and this once done he will discover that tactics are one vast panorama in which each picture is but a development of the previous picture;—one long drama in which each scene grows out of the previous scene. Take one phase of the subject as an illustration,—the fire-formations of Infantry. Montluc tells us that musketeers

[1] "Précis of Tactics", 2nd ed., p. 226.

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were formed in 10 ranks in 1552.[1] In 1670 Sir James Turner says they were in 5 ranks.[2] The English and French musketeers were in 4 ranks about Marlborough's time[3]. The ranks fell to 3 in the time of Frederic the Great[4]; in 1803 Sir John Moore formed the Light Infantry he had created in two ranks,[5] which were adopted by Sir Arthur Wellesley in Portugal in 1808[6]; and the introduction of the breech-loader was followed by 1 rank, with intervals between the files. Now, what was the cause of these successive changes? The gradual improvements in the precision and rate of fire of the musket, which in their turn were the effects of the progress of Chemistry. Metallurgy and the mechanical arts. There must, then, be some invisible link connecting science and war? Though De Quincy lived before "the Struggle for Existence" was a recognised phrase, he reveals the hidden link in his own happy words:—"war (is) a game in which each side forces the other into the instant adoption of all improvements, through the mere necessity of self-preservation". Adam Smith hinted at the same conclusion a generation earlier:—"the state of the mechanical, as well as of some other arts with which it is necessarily connected, determines the degree to which (the art of war) is capable of being carried at any particular time."[7] Such in brief were the steps of a long evolutionary process: the process of science and art which from time to time provided stronger explosives and tougher metal; the ceaseless stress of "the struggle for existence" which moved soldiers to profit by these improvements; the reduction of the ranks of Infantry which followed, step by step; and the modifications in tactics resulting from more effective fire and altered formations.

The opinion of the officer, then, on the worthlessness of a knowledge of past military events is unsound. We lose sight of all the antecedents of which the tactics, formation and arms of an army at a given time are the consequents, unless we understand the past; and we lose at the same time the only available indications of the direction of future progress. A knowledge, however full, of the 4th Act of the "Tempest" would enable no one to gather from it the events of the first three Acts, or to foretell those of the fifth.

We now turn to the second fallacy.

According to the arithmetical method, the two cardinal tests of the value of a battle are the numbers engaged and the number of killed and wounded. But does history support this theory? Have all the battles fought by large numbers and with great losses exerted a lasting influence on human affairs? Were the battles that have exercised a lasting influence on the history of the world invariably fought by very large armies and distinguished by unusual slaughter?

[1] "Commentaires de Messire Blaise Montluc", Paris, 1821; II, 98.

[2] "Pallas Armata", London, 1683; p. 170.

[3] "Stray Military Papers," by the present writer, London, 1897, p. 23, where the whole question is treated at length.

[4] Ib. p. 24

[5] Ib. p. 46

[6] G. O. Lavos, 3 Aug. 1808, issued while the troops were still on board the transports.

[7] "Wealth of Nations," Roger's ed., II, 280.

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At the battle of Zorndorf,[1] 1758, 78,000 men were engaged with a loss to the Prussians of 37·5%, and to the Russians of 50%; yet notwithstanding this almost unequalled carnage, the battle is barren of either tactical or historical interest. At Eylau, 1807, 153,000 men were engaged, the Prussians losing 21% and the Russians 27%; yet this butchery exerted no more historic or political influence than that at Zorndorf. Both were Pyrrhic victories.

The battle of Austerlitz, 1805, fought by 153,000 men, with a loss to the French of 17% and to the Austro-Russians of 30%, produced an immense sensation at the moment. When Mr. Pitt was told of Napoleon's success, he declared it was time to roll up the map of Europe; yet the battle lost its significance within nine years. The battle of Königgrätz, 1866, fought by 436,000 men, with a loss of 4% to the Prussians and 14% to the Austrians, was an important battle, with an influence that extends to the present time. But a great effect, Asiatic as well as European, was created in 1882 by 15,000 British soldiers who, with a loss of 3%, won the battle of Tel-el-Kebir, thereby conferring on England the incalculable advantages political and commercial, naval and military, resulting from the occupation of Egypt.[2] But little interest was created at first in Europe, although a great sensation was made in Asia, by the battle of Plassy, 1757, won by some 900 British soldiers backed by some 2000 Sepoys, with a loss of 2·2%. On this slight foundation was built our Indian Empire, with all the vast power and influence it implies.

Considerable danger to Christianity was averted in 732 by the defeat of Abd-er-Rahman and his Saracens by Charles Martel at the battle of Tours. Had he failed, says Gibbon, "perhaps the interpretation of the Koran would now be taught in the schools of Oxford, and her pupils might demonstrate to a circumcised people the sanctity and truth of the revelation of Mahomet." The enormous numbers given by the Monkish chroniclers for the troops engaged and for their losses are incredible, and Hallam ("Middle Ages," I, 7), supported by Sismondi and Michelet, believes "that the slaughter at the battle was by no means immense." In any case civilisation was not menaced at Tours, for the good reason that the only home of civilisation during the Dark Ages was the territories governed by the Moslems. To their honour be it said that it was the Moslems, and they alone, who kept alight the lamp of learning during this dismal and benighted period.[3] Civilisation, however, was in serious danger of being crushed, if not totally extinguished, by Attila and the Huns at the battle of Châlons, 451. Though not a final, it was certainly one of the decisive battles of the world; yet

[1] I am much hampered in my choice of illustrations, on the one hand by the official ban against the battles of the present war, and on the other by an unwritten, but equally stringent ban against battles that might be displeasing to any of our Allies.

[2] In 1827 Goethe expressed his "wish to see England in possession of a canal through the Isthmus of Suez" (Eckermann' "Conversations &c." p. 223). But this was a generation before Germany adopted 'Blut und Eisen' for her national motto.

[3] Dozy, "Hist. des Musulmans d'Epagne" Leyden, 1861. Nicholson's "Literary Hist. of the Arabs", 1907; Chaps. VIII and IX.

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here again the figures of the sainted chroniclers are unworthy of belief, and we must rest content with the strong probability that the armies were large and their losses great.

When we turn to the battle of Gaugamela (Arbela), 331 B.C., we find that the figures for the strength and loss of the Persian army are not to be trusted. The battle was decisive and of supreme moment, for it placed Asia at the feet of Alexander the Great; but all that can be reasonably added is, that the Greeks numbered about 50,000 and suffered little loss, and that the Persians were many times the number of the Greeks and suffered much loss. None of the preceding battles exerted so deep and lasting an effect on the course of humanity as Marathon, 490 B.C., won by about 24,000 Greeks, with a loss of 192 men, from a Persian army of about 120,000 strong which lost about 6,400 men, many of whom perished in the marshes or were drowned.[1] "In comparison with the military events of our time, the military events of antiquity seem like mere child's play, if we look at physical dimensions alone, and not at world-historic significance. Ignoring the latter point of view, Mr. Robert Lowe has maintained that the battle of Marathon was an event of less importance than *a good colliery accident*, because forsooth only 192 lives were lost on the side of the Greeks! To him, however who has acquired the habit of looking at European history as one connected whole, it will not seem extravagant to say that contemporary English civilisation is indebted to the victory of Marathon in a far higher degree" than to any victory between the 14th and 19th centuries. "If little Greece had been swallowed up by giant Persia, and the nascent political and intellectual freedom extinguished in Athens as it was in the Ionic cities of Asia Minor, the entire future history of Macedonia, of Rome and of Europe would have been altered in a way that is not pleasant to contemplate. When we reflect on the enormous place in human history which is filled by the products of Athenian intellectual activity during the two centuries succeeding the battle of Marathon; when we remember that the foundations of philosophy, of exact science, of æsthetic art in all its branches, of historic and literary criticism, and of free political discussion, were then and there for ever securely laid; when we consider the widely ramifying influences . . . . of all this intense productivity upon Roman ethics and jurisprudence, upon the genesis of Christianity, upon the lesser Renaissance of the 13th cent. and the greater Renaissance of the 15th cent.; when we see how inseperably the life of Athens runs as a woof through the entire web of European life down to our own times;—when we come to realise all this, we shall begin to realise how frightful was the danger from which we were rescued at Marathon and Salamis."[2]

Of the battles that have been named, Marathon, Gaugamela, Châlons, Tours, Plassey, Königgrätz and Tel-el-Kebir all affected the history of the world in a greater or less degree. In some of them

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[1] I follow Bishop Thirlwall, "Hist. of Greece," II, 269.

[2] "Outlines of Cosmic Philosophy," by John Fiske, M.A., LL.B., formerly Lecturer on Philosophy, Harvard University: London, 1874; II, 261-2.

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great numbers were engaged, and in others small numbers; the losses incurred in some cases were great, and in others small. The figures plainly show that there is no necessary connexion between the world-influence of a battle on the one hand, and on the other the number of the combatants and the magnitude of their losses. The value of a battle cannot be calculated by the Rule of Three.

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ARTILLERY AEROPLANE RANGING BOARD.

By Captain F. A. Kirby, R.G.A.

FOR some time past a practical instrument has been badly wanted for quickly converting aeroplane observations of shell bursts into actual gun requirements.

The present service method simply converts the observations into yards, plus or minus, and minutes right and left of the target. Furthermore, it is far from being "fool proof."

In using the service instrument, which is made of cardboard, to find the number of yards plus or minus, it becomes necessary to trace an imaginary line from the actual aeroplane observation, horizontally across the side of the board. To find the minutes deflection right or left, an imaginary line has to be dropped vertically, from the observation to meet the correct deflection scale according to the range. In the majority of cases, it is quite possible to read the wrong scale.

Undoubtedly the present instrument fails in this respect.

On service, is felt the want of an instrument which will quickly and accurately tell the Battery Commander where his round fell with reference to the gun or howitzer.

I would suggest that an ordinary instrument made and worked on the following lines will greatly assist any Battery Commander.

Calculations :

From the range table, interpolate ranges for every degree elevation, and tabulate. Note the differences in range between each adjacent range,—that is, the value of one degree elevation at that range.

Calculate the lateral distances due to one degree deflection at the above interpolated ranges. (See following table).

Marking :

Select a suitable scale at which to engrave an 8in. circular protractor and mark the board. A scale of $\frac{1}{4000}$ will be found most suitable.

To engrave the circular protractor :—

This can be done with the aid of a sewing needle fitted to a pair of compasses. From the centre of the protractor describe circles representing the circles "Y" to "D", to the scale of $\frac{1}{4000}$ and letter the circles.

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Extracts for 6-in. Howtizer 26 cwt., Charge 4.

Elevation. (1).	Interpolated Ranges. (2).	Difference in Ranges. (3).	1° Deflection at Interpolated Ranges. (4).	Charge 3 Equivalent Ranges. (5).
35°	9850		171×	7350×
34°	9755	95×	170	7235
33°	9650	95×	169	7105
32°	9540	110	168	6965
31°	9410	130	165	6825
30°	9265	145	162	6670
29°	9115	150	159	6500
28°	8945	170	156	6330
27°	8765	180	152	6155
26°	8570	190	149	5970
25°	8370	200	146	5765
24°	8155	215	143	5565
23°	7935	220	139	5360
22°	7700	235	135	5140
21°	7480	220	131	4910
20°	7240	240	126	4670
19°	7000	240	122	4425

Engrave the diameters to represent the hours of the clock, and stamp the figures accordingly, with 12 at 360 degrees.

The sewing needle will make quite a clearly defined line on the celluloid.

Do not pierce a hole through the centre of the protractor, as by so doing, the "Y" circle would be covered eventually by the head of a drawing pin.

For holding the protractor in position, it is much better to have a hole made in it, at about an inch from the outside, on either side of the centre.

To mark the board :—

A convenient size of board is 26″ × 9″ × ½″. This will enable two sheets of ordinary plain foolscap to be pasted on.

Across the board, draw parallel lines to represent the ranges in col. (2) of table. The distances between the parallel lines should correspond to the differences in ranges (col. 3) to the scale of $\frac{1}{4000}$.

Divide up the intervening spaces into three by drawing a thin line. These each represent 20 mins.

Against the degree lines mark the actual interpolated ranges from col. 2.

Down the centre of the board, draw a line at right angles to the parallel lines, and mark it "Zero."

Using the distances in col. 4, mark on each side of the zero

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line, the degree deflection lines. This need only be done at a short and a long range, and the points joined up.

Divide the intervening spaces into three by drawing a thin line. Each of these will represent 20 minutes deflection.

To set the instrument:—

The centre of the graduated protractor must be on the intersection of the zero line on the board, and the degree line representing the range nearest to the battery range to target.

Turn the protractor round until the angle on it, cut by the zero line, is the same as the true bearing of the target. (See sketch.) With the aid of two drawing pins, rigidly fix the protractor in position on the board.

Example in sketch:—

Battery range 8400ˣ

True bearing 60°

The centre of the protractor is set on the degree line representing 8370ˣ

A round reported as having fell at C 12 was actually 30 minutes over and 1° 10 Left.

With this information readily to hand, the subsequent corrections to bracket the target can be quickly seen.

NOTES.

It has been found practically that it is quite sufficient for the range degree lines to be drawn straight and not curved. Errors due to this will only occur in cases where first rounds of guns are much out of line, in which case, the personal error of the aeroplane observer creeps in.

With some natures of ordnance, it will be found, that a ranging board made on this principle can be used for varying charges. The dependent factors being the equivalent in yards due to one degree elevation and deflection. In the case of the 6-in. Howitzer, 26 cwt., the ranges shown in Col. 5 are the Charge 3 equivalent ranges to Charge 4; but for deflection, a correction equal to half as much again, would have to be used for Charge 3.

Generally, a ranging board for each charge would have to be made, thus avoiding any complicated factors.

It is sufficiently accurate enough to make the divisions on the range board equal to amounts not less than 20 minutes. Where required, a quarter of the divisions can easily be read off. The chief point to bear in mind is that the least number of lines on the range board, the better. A considerable number of unnecessary lines tends to make the application of this practical instrument very complicated.

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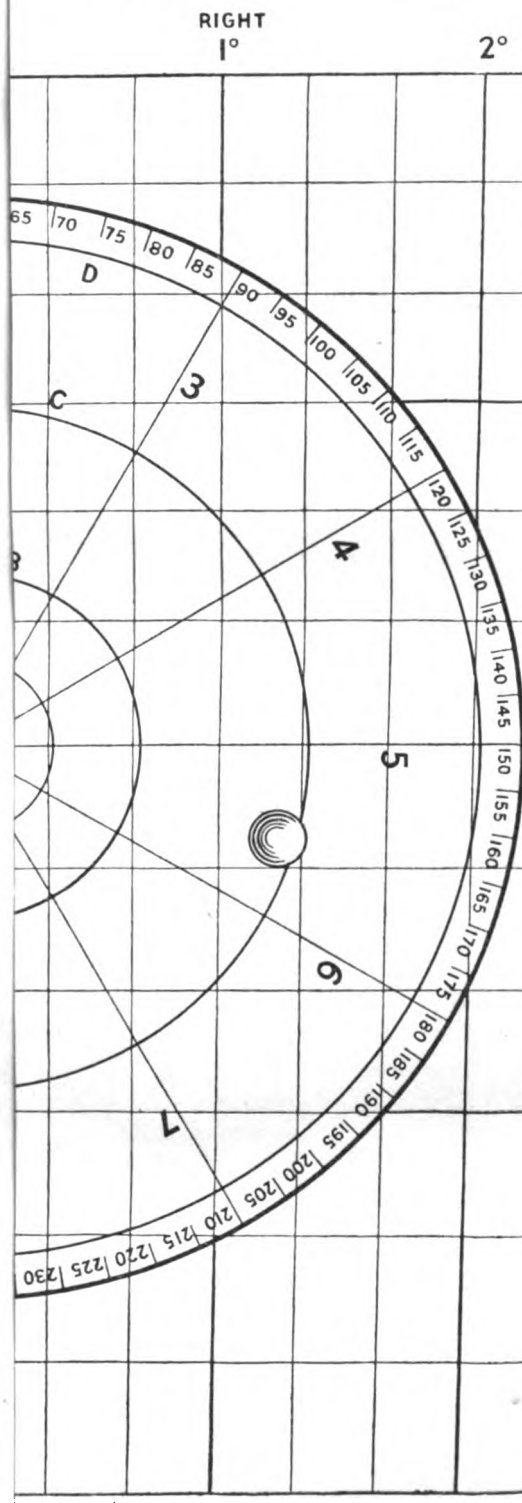
E RANGING BOARD.

vt. Charge 4. (Scale $\frac{1}{4000}$).



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THE USE AND ABUSE OE THE DEFLECTION FACTOR.

BY ANON.

IF an observer is in the battery, he can observe the exact amount right or left of the target that the shell bursts and alter the deflection accordingly. This will however rarely be the case, and the Observer will generally be forward and also to a flank.

The case where he is forward and in the line battery-target will be considered first. The amount right or left observed by him will obviously not be the amount of correction required, and to find the latter it is necessary to apply to the observation the factor $\frac{O.T.}{B.T.}$

This used to be called the line factor but is now more commonly known as the deflection factor. The results obtained by its application are not theoretically correct but for practical purposes can be taken as correct, unless the shell falls considerably out for range. (It is obvious that if the observer is close to the target and the shell falls far short and is out for line, very considerable errors would ensue from the application of the deflection factor but generally the results would be practically accurate).

If the shell falls range or nearly so, then the result obtained by applying the factor could be taken as exact.

With the observer well forward however, he will be to a flank of most targets, and the question then arises as to whether the factor $\frac{O.T.}{B.T.}$ can still be used.

The following table shows the approximate errors at various apex angles, if the factor $\frac{O.T.}{B.T.}$ is used.

Apex angle.	Error.
20°	8%
30°	16%
40°	32%
50°	64%
60°	100%
70°	200%

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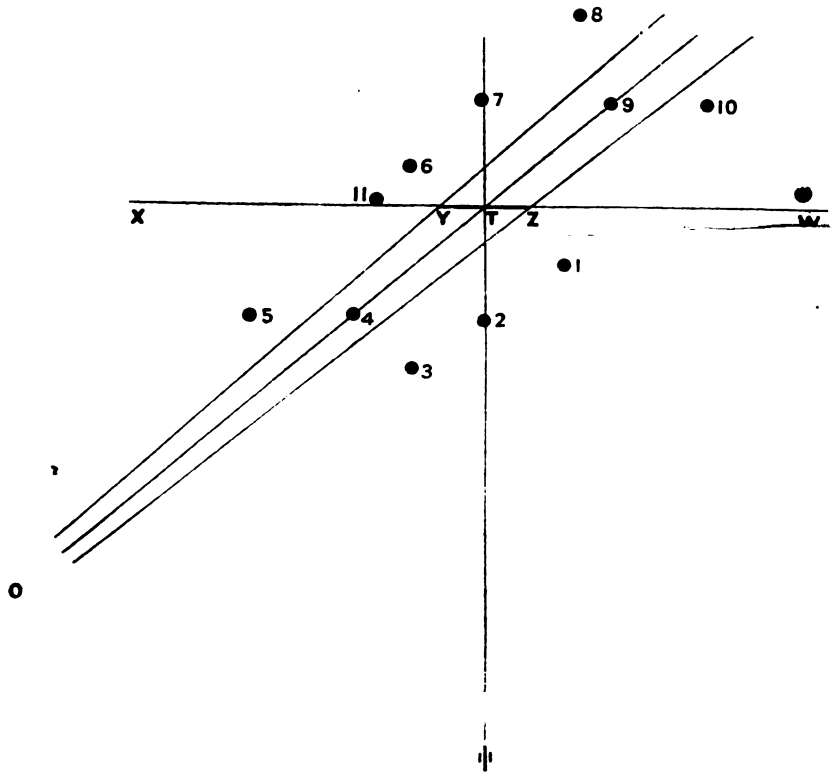
The results are independent of the value of $\frac{O.T.}{B.T.}$ i.e. there will be an error of 32% at 40°, whether $\frac{O.T.}{B.T.}$ was ⅛ or ½.

e.g. Apex angle 60°. Shot falls 6° R. OT = 1000. BT = 6000.

$\frac{D}{O} = \frac{1}{3}$ Correction = 2° M.L.

but $\frac{OT}{BT} = \frac{1}{6}$ Correction = 1° M.L. a 100 % error.

From this table it will be seen that the factor $\frac{O.T.}{B.T.}$ gives results too inaccurate to use, if the apex angle is 30° or over, and another factor should be used instead. This other factor can be obtained in different ways. The simplest is to read it off a nomograph or get it from the "Table of Angles." It can also be quickly found on the slide rule; if no nomograph, table of angles or slide rule is available, a good approximation can be made for the above table, the figures of which once seen, can hardly be forgotten.



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Thus, apex angle 60°, $\frac{\text{O.T.}}{\text{B.T.}} = \frac{1}{4}$, error is 100% and the deflection factor is $\frac{1}{4} + \frac{1}{4} = \frac{1}{2}$.

This is the factor used, when ranging, on the line of observation, if it is desired to bring a round on the line of observation by deflection.

When however visualising on a flank, a B.C. should not apply this factor to rounds falling + or –, *and the factor only gives good results when the shell falls range or nearly so.*

In the figure, the B.C. is on the left flank. The target is a piece of trench Y Z, part of a long trench X W.

Rounds 1, 2 and 3 are all observed as minus, and right along O.T., but they may be right (1) line, (2) or left (3) and the deflection should not be altered unless it can be seen by visualising B.T. or by the lie of the ground that the line is wrong. Round (4) is observed as line and – along O.T. and is a certain left and enough right deflection should be given to start a deflection bracket. A round minus, and left of O.T., is also left and a deflection bracket should be made.

Again as to plus rounds, rounds 6, 7 and 8 are all observed as plus and left along O.T., but they may be left (6) line (7) or right (8) and the deflection should not be altered unless it can be seen by visualising B.T. produced, or by the lie of the ground that the line is wrong. Round (9) is observed as line and plus along O.T. and is a certain right, and enough left deflection should be given to start a deflection bracket.

Round 10 is observed as plus and right along O.T., is therefore right and a deflection bracket should be made.

In none of the above cases does the deflection factor afford much help.

Round (11) however falls range or nearly so, and if the B.C. observes the amount left that it falls, and applies the deflection factor, he gets the exact amount of deflection required to bring the next shell on to the desired point. Also if there are other points in the trench which he desires to hit, all he has to do is to measure the amounts right or left of the last target and apply the deflection factor, i.e. provided the trench is approximately at right angles to the line of fire.

There is a very prevalent idea that if the apex angle is small, say 10° or below, the deflection factor can be applied to any rounds with equally good results as if the observer was in the line battery target, no matter whether the rounds are close to the target for range or not.

This is absolutely wrong.

For example, presume the observer on the left flank, O.T. = 700, B.T. = 3500, apex angle as small as 5°, and the first round falling line and – 150 yards.

This will appear as 1° 40′ Right and if the B.C. applies the deflection factor, he would give 20 minutes more left whereas no correction for line was required at all.

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To sum up: when the observer is to a flank, the deflection factor should be known, but for any apex angle over 30° it is inaccurate to use $\frac{O.T.}{B.T.}$ and it should be found by some other method as explained above.

It should however not be applied to any and every round, *even with very small apex angles*, and it is only true when the round falls range or nearly so, it is then extremely useful.

The B.C. should not alter his line unless he has direct evidence that it is wrong.

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DUTIES OF A SUBALTERN OFFICER IN FRANCE.

By 2nd Lieut. R. P. Prentys, R.F.A.

WHEN a subaltern joins a field battery in action in France or Flanders there are a considerable number of facts, (relative to the battery to which he is posted) to be absorbed by him before he becomes efficient, or can face with equanimity a visit from his Colonel or Brigadier, either at the battery or at the O.P.

It rarely happens that the B.C. or senior subaltern has the necessary time to instruct new officers in great detail. In the majority of cases, therefore, necessary facts are only acquired slowly and laboriously, frequently at the cost of a diet of humble pie, the unlucky subaltern only discovering his lamentable ignorance when suddenly questioned by a staff officer concerning some matter the very existence of which he has been unaware.

The aim of these few notes is to outline to the young artillery officer the most important facts with which he should acquaint himself while his battery is engaged in the present form of stationary warfare. Also to give hints as to where the necessary information may be gleaned in order that he may direct his enquiries with intelligence. Until the young officer has familiarised himself with these facts and added them as an appendix to his Gunnery Notes he should allow himself no peace of mind.

1. Map reference of the Battery Position, Zero Point and O.P.

2. The contour on which the battery is located (required for calculating angles of sight). If as accasionally happens, the battery is in action on a slope, learn whether the same contour is used for calculating the angle of sight with the highest as with the lowest gun.

3. Are lines of fire parallel or concentrated?

4. Learn the gun intervals between the pits—prepare a table of concentrations for these intervals at the ranges commonly used, so that the necessary orders may be quickly given to concentrate all guns on a point, or to bring lines of fire parallel.

5. Learn the true bearings of the average line of fire of the guns, for calculating windage corrections.

6. Enquire from the B.C., or the No. 1's of each subsection, the maximum switch R. and L. of Zero which each gun pit will allow of, and the ranges at which they will clear the crest at the various switches.

7. Enquire as to the calibration of the guns in the battery.

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Also whether any guns have any peculiarities and shoot either "over" or "short".

8. Learn whether daily tests of sights are made, and, if so, by whom.

9. Secure from the battery clerk a registration book. (A.B.421) and make a copy of the map spotting, angles and normal ranges of all targets registered, Night, Day and S.O.S. lines, Hostile Trench Mortar and Machine-gun emplacements, special targets, etc.

10. Learn the tour of duty of the various officers in the battery—usually comprising duty at the O.P., with the guns, and liasion duty with the infantry.

11. Ascertain whence the ammunition is drawn—whether from your own wagon line, B.A.C. or D.A.C., and, if the latter, the map reference, the telephone call and the best routes.

12. Know the map reference of your own wagon-line, the route to it, and its telephone call.

13. Memorize the number of the Infantry Brigade covered by the battery, the map reference of its H.Q. and the battalions comprising the brigade.

14. Learn the map references of the Company H.Q. and Battalion H.Q. of the infantry unit in the line which the battery covers.

15. Procure from the battery files a trench map of our own trenches in the battery sector and make a careful study of it.

16. Enquire from the B.C. what codes are in use, also the word for use with the Playfair code, and the key to the "number code".

17. Learn the position your Brigade occupies in the Division—Right Group, Centre or Left Group. Likewise the battery position in the brigade—Right, Centre or Left—and the sector on the map which it covers.

18. Learn from the Signaller N.C.O. the telephone call of all the batteries in the brigade, Brigade Headquarters and Divisional Headquarters.

19. Learn the map position of all rocket stations for S.O.S. signals, and what the S.O.S. rocket signal is. (This information can usually be obtained from the Brigade Signals Officer).

20. Learn all you can from the Signaller N.C.O. of the battery, concerning the battery lines of communication. What lines there are, where they lead, whether they are "air" or "buried", the routes taken, the labels on the wires, the positions of test boxes and exchanges, and the identification marks of terminals. Add to your notes a "straight-line diagram of these wires."

21. Learn from the same source what arrangements there are for visual signalling by day and night between the front line and O.P. and between the O.P. and battery.

22. Enquire whether it is the practice of the battery to fire a fixed number of rounds of shrapnel every day for the purpose of determining the "corrector for the day", and also obtain information as to ammunition allowance, and the proportions of H.E. and Shrapnel.

23. Learn for what ranges the correction for the day is calculated, and how often during the 24 hours the correction is made.

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24. Learn the difference which is allowed between gun range and map range for H.E. and Shrapnel shells. (Fifty yards is usually dropped from the map range when using H.E. though the allowance may vary with different ranges and under different conditions).

25. Obtain from the Battery Clerk the "Précis of Artillery Arrangements", and carefully digest contents. Understand thoroughly what procedure is adopted when an S.O.S. call is received from the battalion on the immediate front, on the Right or on the Left. Familiarise yourself with the method of retaliation on active hostile Trench Mortars, and what to do when a gas alarm is given.

26. From the same "Précis", master the actions of the battery for any defence schemes which may have been prepared and take an early opportunity of visiting the selected defensive positions. Do not fail to familiarise yourself with the routes to these postions.

27. Enquire as to what restrictions there are when talking by telephone—whether the direction of fire from the O.P. is done by map reference or by angles from the Zero point.

28. Enquire as to list of targets which may be awaiting registration by aeroplane co-operation. Obtain the map spotting and the code names by which these are known, so that you may have the angles and ranges calculated ready for immediate use if such are called for by the R.F.C.

29. Learn the existing local traffic regulations enforced by the A.P.M.—overloading wagons, led horses, exercising on main roads, etc.

Some of the details mentioned in the foregoing paragraphs may seem trivial, but in reality the possession of a knowledge of them may, at any moment, become of supreme importance to a junior officer, and the time spent in mastering them is well laid out as the writer knows from his own personal experience.

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A METHOD OF ESTIMATING GUN CORRECTIONS.

By Major G. H. King, D.S.O., R.A.

THE method given below has been found by the writer to be a quick and accurate way of estimating the various corrections due to temperature of charge, etc. from the data given in the Range Tables. It is claimed that by this method much time is saved, and risk of errors due to slips in mental arithmetic are as far as possible eliminated.

The case considered is that of a 4·5 Howitzer Battery, but the method would apply equally well to 18-prs., except that the latter case would be far simpler as there would be only one charge to consider.

The only materials required are some colored pencils and an ordinary army book with squared paper, though if procurable larger sheets of paper ruled with squares of one eighth of an inch would be better, as the diagrams would then be clearer.

The corrections are classified under the three following headings:

A. Corrections due to the height of the Barometer and to the temperature of the Charge and of the Air.

B. Corrections due to the wear of the guns.

C. Corrections due to force and direction of the wind.

A. *Corrections due to the height of the Barometer and to the Temperature of the Charge and of the Air.*

The values of the corrections at every 500 yards of range, due to the above three causes are plotted at a suitable scale on a set of rectangular coordinates as in the example shown in Figure 1. The corrections due to the three different causes should be plotted on three different diagrams. The corrections for each separate charge should also be plotted on a separate sheet. If this is not done it will be found that diagrams will become confused and difficult to read quickly. For the convenience of quick reference it is advisable to keep the diagrams relating to any one charge pinned together.

A convenient way of making the graphs, is to plot the values in yards due to each rise or fall of 10° of temperature or ½ inch of barometer for every 500 yards of range, and to draw curves through the points so obtained.

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The diagram shown in Fig. 1 is made as follows: A pair of rectangular axes X and Y are drawn on squared paper. Range is plotted at a scale of 100 yards to one quarter of an inch on the X axis. Correction is plotted at a scale of 10 yards to one quarter of an inch on the Y axis. The value of the corrections for each 10° rise or fall in the temperature of the charge is obtained from the Range Table as follows: At the beginning of the N charge range table is found a note that for N.C.T. Temperature Corrections, 10°F is equivalent to 6·9 foot seconds. The value of this variation of 6·9 foot seconds in muzzle velocity is found from the last column on page 39 of the Table, which gives the variation for 10 foot seconds, the required values consequently are ·69 of the values given in the column. Values for the ranges marked on the diagram are now plotted and a curve drawn through the points so obtained. This gives a curve of 10°, from this curve ones for 20° and 30° are easily obtained, as the values of the y ordinates are simply multiples of those for 10°. For this charge a separate set of curves will be required for cordite, which can be drawn on the same diagram only in a different colour. They are omitted in Fig. 1 for the sake of clearness. Diagrams to show corrections due to temperature of the air and the height of the barometer, can be drawn in a similar manner, the ones taken from the V Charge table will be sufficient for all charges, as the values are approximately equal.

To read these diagrams, values other than those shown are interpolated e.g. (Fig. 1): Range 2750 16° F. fall in charge temperature. Correction found at **X** to be + 57 yards.

The corrections for the Height of the Barometer, Temperature of the Charge and of the Air, will be the same at any one time for the whole battery, and can be combined in one curve, which for want of a better term, can be called the curve of the "*Error of the Day*." An example of this is given in Fig. 2. The conditions on this day are supposed to be as follows: Temperature of the Charge (N.C.T.) 45° F., Temperature of the Air 42° F., Height of the Barometer 29 inches. To construct the diagram: Two axes X and Y are drawn as before, Range is plotted on the X axis to any convenient scale. We will suppose that the ranges required are from 2500 to 6500 and that we have decided to plot points on the curve at every 500 yards.

The values for the y ordinate are obtained by combining the corrections for charge, Air and Barometer at each 500 yards of range. The values of these components can be read off very quickly from the primary diagrams described in para. 4, and the calculations can be conveniently tabulated as under.

It will be necessary to take values for IVth and Vth Charges separately.

The curve for the IIIrd Charge approximately coincides with the one for IVth Charge and is not shown separately.

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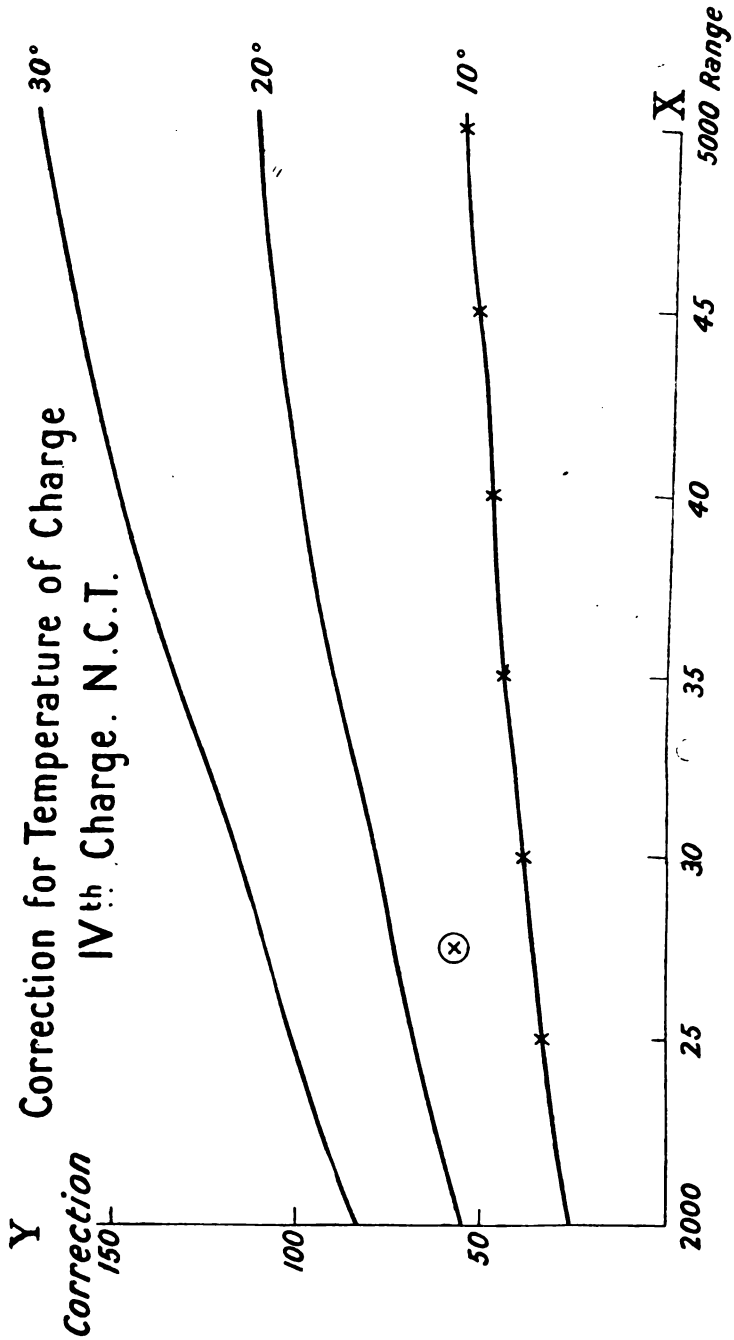

Fig. 1.

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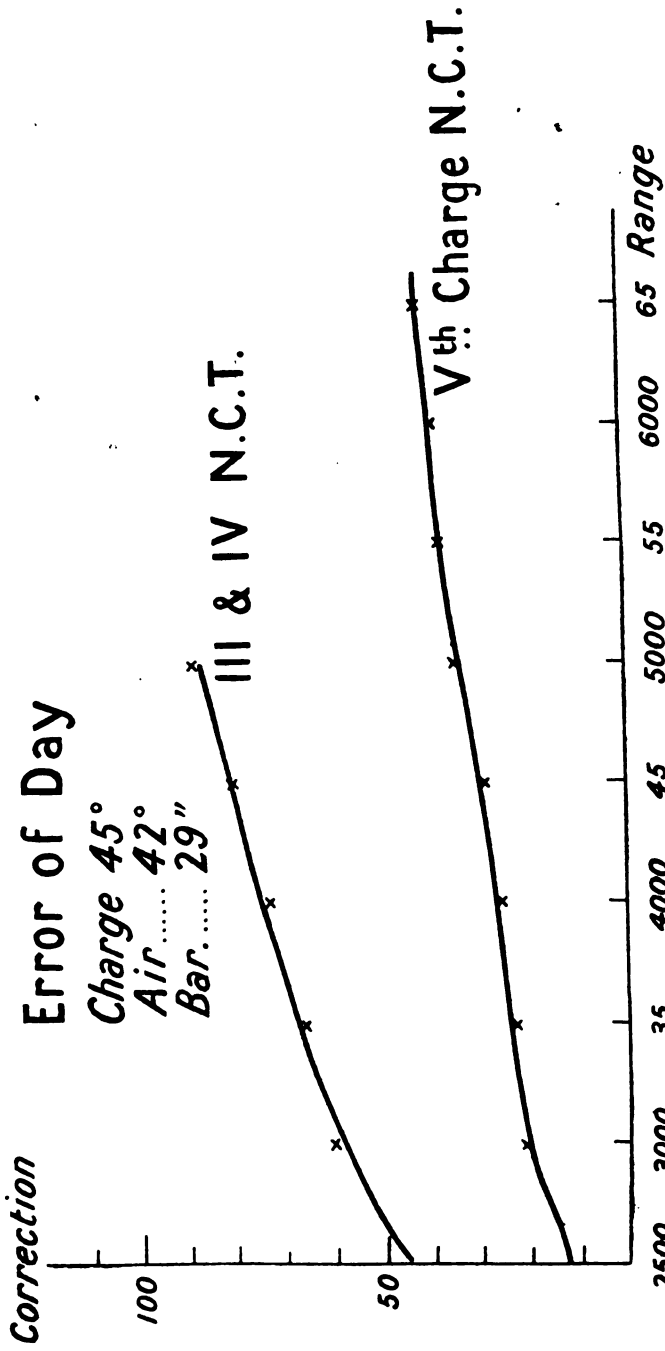

Fig. 2.

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Vth Charge. N.C.T.

Range	Charge 45° − 15°	Air 42° − 18°	Bar. 29 − 1	Total
2500	17	7	− 11	13
3000	21	14	− 14	21
3500	24	17	− 18	23
4000	27	22	− 23	26
4500	30	26	− 27	29
5000	33	35	− 33	35
5500	36	41	− 39	38
6000	37	48	− 46	39
6500	38	57	− 53	42

IVth Charge N.C.T.

Range	Charge 45° − 15°	Air 42° − 18°	Bar. 29 − 1	Total
2500	50	7	− 11	46
3000	60	14	− 14	60
3500	67	17	− 18	66
4000	75	22	− 23	74
4500	82	26	− 27	81
5000	88	35	− 33	90

This calculation can be written on the back of the diagram.

These diagrams should be kept, as conditions are always liable to recur.

A convenient way of filing them is to keep them sorted in ascending values of charge temperature.

B. In addition to the corrections for the "*Error of the Day*", another set of diagrams will be necessary for what may be termed the "*Error of the gun*", or the difference in shooting between the gun and the map under normal conditions. This will be a constant for each gun for each charge and "lot" of propellant, provided that the type and weight of projectile remain the same. It can be easily ascertained by experiments and by using the variation in M.V. column in the Range Table. To construct the diagram, Range can be plotted on the X axis as before and the values of the Y ordinate obtained by plotting the differences between True and Normal Gun Range at the map ranges of the targets fired at, or at the ranges calculated from the variation in M.V. column given in the Range Table. The writer found that the curves were entirely different for N.C.T. and Ballistite. In practice it was found better when arranging this diagram to group the guns together on one diagram, with a separate diagram for each charge and for each propellant. The

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curves can be drawn with a different colour for each gun. By this arrangement the difference in shooting between any two guns was at once apparent by noting the vertical distance between the curves at the range in question. Also the range to a target having been found by one gun, the range of all the other guns to the same target could be seen at a glance. In practice the diagram will probably be found to simplify itself owing to the coincidence of the curves of those guns which shoot alike.

C. As the corrections for wind depend upon the direction of the target, they cannot be included in the "Error of Day" curve, unless the battery is firing on a very narrow frontage. It was found however that a convenient method for resolving the wind into its components affecting Range and Line, was by means of a "Clock" diagram shown in Fig. 3. The reason why a "Clock" arrangement was selected, was, that it was found to save time, as the mental picture of a clock face and the angles subtended by the hours at the centre are so familiar, that the direction of the wind with reference to the line of fire, could be at once estimated at so much o'clock off the map.

The diagram in Fig. 3 is constructed as follows: On squared paper, on a scale of two foot seconds to one quarter inch, 5 concentric

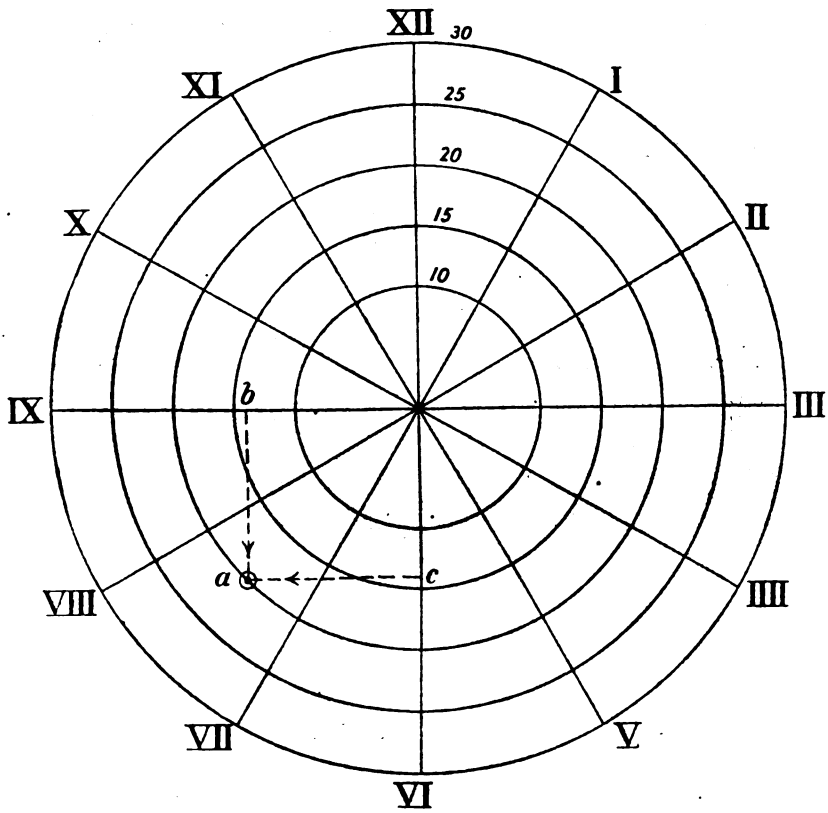

Fig. 3.

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circles are drawn with radii of 10, 15, 20, 25 and 30 foot seconds respectively. The circumference of the largest circle is divided into twelve equal parts for the hours, and diameters are drawn joining opposite hours.

To use the diagram: The battery is always assumed to be at the centre of the circle, and the target to be in the direction of twelve o'clock. Example: Wind estimated at 20 feet per second is found to be blowing from a direction of half past seven o'clock with reference to the line of fire. If great accuracy is required the angle between the line of fire and the wind can be measured in degrees in a clockwise direction, and this angle divided by 30 to bring it to the time and the direction found more exactly. In this case half past seven on the 20 f.s. circle brings it to the point (a). The components for range and line can now be read off by means of the squares along (*ba*) and (*ca*) respectively and, as shown, are 14 foot seconds in each case.

The value of the 14 foot seconds can now be read off in terms of range and deflection on graphs arranged for this purpose. The direction in which both corrections must be applied to counteract the wind, is always outwards towards the circumference of the largest circle. In this case it is minus for range and Left for deflection. For obtaining the value of the foot seconds a separate diagram is necessary for each charge, but the range and deflection could both be plotted on the same axis using the same scales, by adopting for the y axis some such scale as 10 yards or minutes to one quarter inch, and drawing the range curves in a colour different to those for deflection.

It may be thought that there are too many diagrams to handle and use, and that confusion would result from having so many, but it has not been found so in practice. The method of having the primary diagrams relating to each charge pinned together in bundles saves time and confusion, and once the "*Error of the Day*" curve has been made out, it is never necessary to handle more than four at a time, viz: The Error of Day, Error of Gun and the two relating to wind. The writer found that the quickness and accuracy in making corrections which resulted from the use of a similar set of these graphs was well worth the trouble of making them.

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A TIME-RANGE BOARD.

By First Lieutenant Oscar Krupp,
Coast Artillery Corps U.S. Army.

(From the "Journal of the United States Artillery."

The essential features of this board are:

a. The time-range track of the course of the target is plotted with actual ranges and short observing intervals.

b. The corrected set-forward ranges are obtained from this time-range track.

The advantages claimed for it are:

a. It decreases without any effort the time required for obtaining data necessary to open fire to less than one-third the time often taken with the present system.

b. It makes it possible to successfully track a fast moving target on an irregular course.

c. It can be easily operated in the plotting room and under the supervision of the range officer.

DESCRIPTION.

Referring to Figs. 1 and 2, the board can be of any convenient size. A working model has been constructed of slate, on which were graduated the necessary lines. Instead of slate, however, a wooden board could be used with tracing cloth over cross-section brown print. Each five hundred and thousand-yard line should be made heavy to aid the eye in quickly locating the point corresponding to the actual range.

The top edge of the board is parallel to the range lines and graduated to every five seconds. Sliding along this edge is a T-square with a movable pointer and a sliding ruler. The left edge of this ruler is graduated to read corrected ranges; the right edge is graduated to read range corrections. The ruler should be made long enough to allow for any correction that may be applied. The movable pointer is used to indicate the position of the T-square on the time-interval scale at any time and is kept set to the time of flight (in yards) on the range-time-of-flight scale, which can be moved so as to allow for any adopted predicting interval.

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A small straight edge, or plotting ruler, is used to plot the track of the target. The actual plotting may not be necessary though as the corrected range to be sent to the guns is read at the intersection of the plotting ruler and the corrected range scale. For targets going at moderate speeds, the track can be projected ahead with an accuracy within ten yards.

OPERATION.

Having decided upon the observing interval to be used, say 10 or 15 seconds, we regulate the time-interval bell accordingly. The base-end readings are transmitted to the plotting room, and are set

Time-Range Board—designed by Lieut. Krupp, C. A. C.

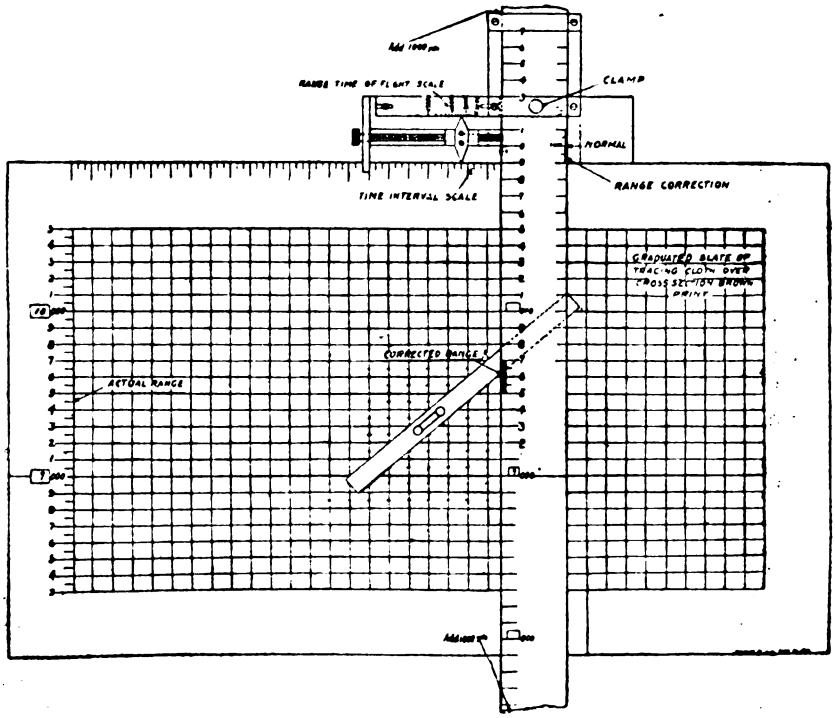

FIG. 1.

by the arm setters as usual except that the arms are not removed from the course of the target after each setting. The actual gun range is read each time and this is plotted on the time-range board.

The operations of the time-range board are as follows: Plot first actual range received from the plotting board. Mark the thousand digits on the actual and corrected range scales, making the normal of the corrected range scale and the normal of the board the same. Set the movable pointer at the range. Set the range correction to the reference number received from the range board. The present range-board operator makes corrections as usual, but instead of

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obtaining the corrected range he reads the range correction reference number. Move the T-square so that the lower end of the movable pointer is directly over the second or any subsequent actual range. Repeat operation as often as data is received. Align the plotting ruler along actual range points, projecting the end under the T-square. At any time, or interval desired, read the corrected range on the corrected range scale and then advance the T-square to the right to its new position. The T-square can be set so as to send the range to the guns every interval, or as desired. Corrected ranges, based on the last observation, can be sent to the guns and be set on the range drum ready to fire in 15 seconds.

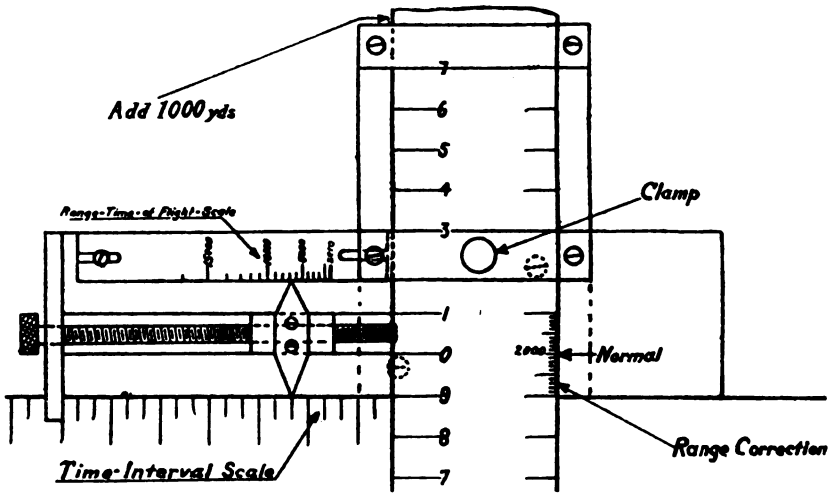

FIG. 2.
Upper part of T–Square enlarged.

At a recent test a 15-second observing interval was used and the range-time-of-flight scale was set so as to allow also for a predicting interval of 15 seconds. This made it possible to co-ordinate data without the use of a stop watch, and the corrected range based on the last observation was set on the range drum in time to fire on the following bell. The telephone headset at the emplacement was worn by the range setter who was thus in direct communication with the plotting room.

Range corrections were applied to the corrected range ruler of the time-range board by using a range reference number. A pencil index and a 2000 normal were marked on the range ruler of the Pratt range board. Corrections for wind, tide, atmosphere, and muzzle velocity were made as usual.

The observed points were plotted on the plotting board every 15 seconds. The actual gun range of these points was used as a basis for the time-range track. The actual plotting of the time-range track required but a few seconds at the most since the plotting ruler gave the corrected range at any time, it being unnecessary to project the course ahead by dotted lines.

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The only work required of the time-range board operator was to continue the track of actual gun ranges. Another person with a headset read the corrected ranges directly to the range setter. This man also set the T-square of the time-range board for the next bell immediately after reading the last corrected range, and set the range-time-of-flight scale whenever it was necessary.

Corrected range data for opening fire was sent to the guns in 30 seconds after the first observation was taken, this time being dependent upon the first range correction. Consequently, under usual conditions the first shot could have been fired on the 3rd bell or at the latest on the 4th bell, or 45 seconds after the first observation, provided of course the guns had been loaded at this time.

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NOTES ON THE TIME-RANGE BOARD DESIGNED BY LIEUT. KRUPP, C.A.C.

By Colonel WILLIAM G. HAAN, Captain JAMES P. ROBINSON, and First Lieutenant ROBERT D. BROWN, C. A. C., U. S. Army.

(From the "Journal of the United States Artillery."

The mechanical device for range correction involves the principle of the Whistler-Hearn plotting board, making correction upon the last observed range instead of the range of the predicted point; it is, therefore, a source of small errors (probably negligible).

The range-time-of-flight scale makes for speed and accuracy; it is very simple and, if properly constructed mechanically, the operation can be performed very quickly.

The mechanical features of the board for use indoors can be made to work satisfactorily. It is suggested that the T-square be made to move by a worm gear with crank at top of right edge of board. It is also suggested that, in addition to the range correction scale, an arbitrary correction scale be put on which will move the range arm together with the range correction scale so that at any time an arbitrary range correction can be made without disturbing the continuity of range corrections received from the range correction board. It is thought that this can be easily done, by mounting this additional scale either in connection with the range correction scale or separately from it.

The radical departure from the present method is that the board is to be used for predicting range to set-forward point, thereby reducing the work on the plotting board and permitting a smaller observing interval. This will reduce the time between the last observation and instant of splash.

The demands upon the skill and judgment of the plotter are greatly reduced, since he is required only to plot the actual range and read it from gun arm; an operation which can be done in a much reduced time—a very desirable result.

It eliminates the uncertainties and annoyances of stop watches, as with this board they are not required. It also reduces the personnel as follows:

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a. Eliminates set-forward drum and operator.

b. Where 4 men are now required with time-range board used at the guns, or 2 men if used in plotting room, this board requires but 1 man.

A valuable feature is the reduction by more than one-half of the time required in getting data to fire the first shot.

The probable errors in range, due to prediction on the time-range board instead of the plotting board, should be no greater for the same period of prediction, and should be less if by the use of this board that period can be reduced. The assumption frequently made that ships of a fleet will continue on a curved course is not justified. Fleets are, and of necessity must be, manœuvered on lines of bearing, and changes in course are made only to get a new line of bearing ordered on which new course they then continue. This feature has been fully discussed with naval officers who insist that all their tactics necessarily require ships to run on courses and not in curves. The direction, of course, is frequently changed, but the order is given to change so many degrees to the given bearing of the new course. After the change has been made, the new course is run in a right line. It is, therefore, erroneous to assume on the plotting board that the target will continue in a curve if the last several observations indicate a curved course. It means that the ships are turning to again continue in a straight course.

A careful study of actual courses run by the battleships *Rhode Island* and *Georgia*, diagrams of which have been kindly furnished by the Navy, shows that a battle-cruiser going at 24-knot speed, and without changing its speed, but changing its course only, can be away from the set-forward points for the various predicting intervals, distances as shown in the following table:

(Speed of ship—24 knots).

	Time from observation to set-forward point.	Distance of target from set-forward point.	First order of differences
1	15 seconds	40 yards	40
2	30 ,,	185 ,,	145
3	45 ,,	410 ,,	225
4	60 ,,	700 ,,	290
5	75 ,,	1040 ,,	340

This table shows the extreme importance of reducing the time between the instant of last observation and the instant of splash. It is evident that if the predicting interval can be reduced, it will tend to shorten the period between the instant of observation and the instant of splash, and, therefore, will eliminate that part of this period in which, as is readily seen from the above table, the possible rate of moving away from the set-forward point is greatest.

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This board is especially adapted, and will be seen in its most favorable light, when its use is considered in connection with the long self-contained base range-finder. Under such conditions of range finding and prediction, there would be made possible extremely short intervals of observation and prediction, and, consequently, as deduced in the previous paragraph, a reduction of probable errors.

After careful study, the writers are of the opinion that this device should have serious consideration by those who are responsible for seeing that our Coast Artillery equipment keeps abreast with improvements in other lines.

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ERRORS IN LINE WHEN LAYING ON NEAR AIMING POINTS, & THEIR ELIMINATION.

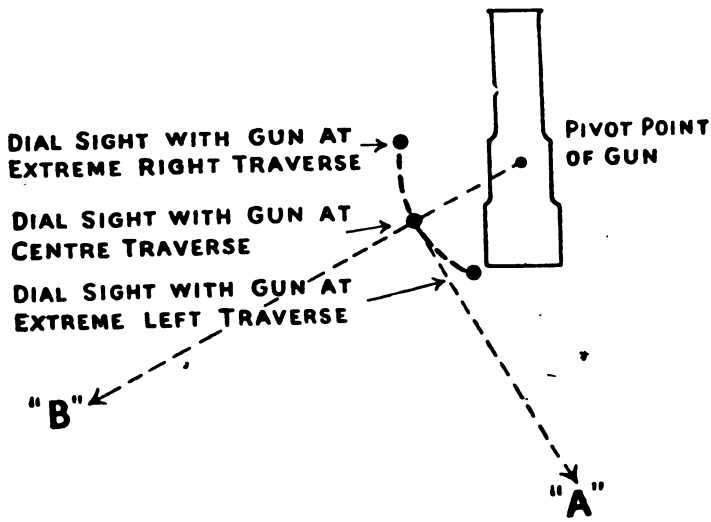
By Lieut. M. McGillewie, R.G.A.

It happens, invariably by night, and frequently by day, that an aiming point near the guns must be used.

Suppose the A.P. to be 100ᵡ distant, then every 5′ lateral displacement of the dial sight with reference to the A.P. causes an error of 5′ in the Line.

With guns on fixed mountings, such as the 9·2″ How. this error can be almost eliminated—*provided that the platform remains steady and does not creep to the rear*—by choosing the position of the A.P. so that a line from it to the dial sight when at centre traverse is a tangent to the arc described by the sight when traversing.

The following sketch will make my meaning clear:



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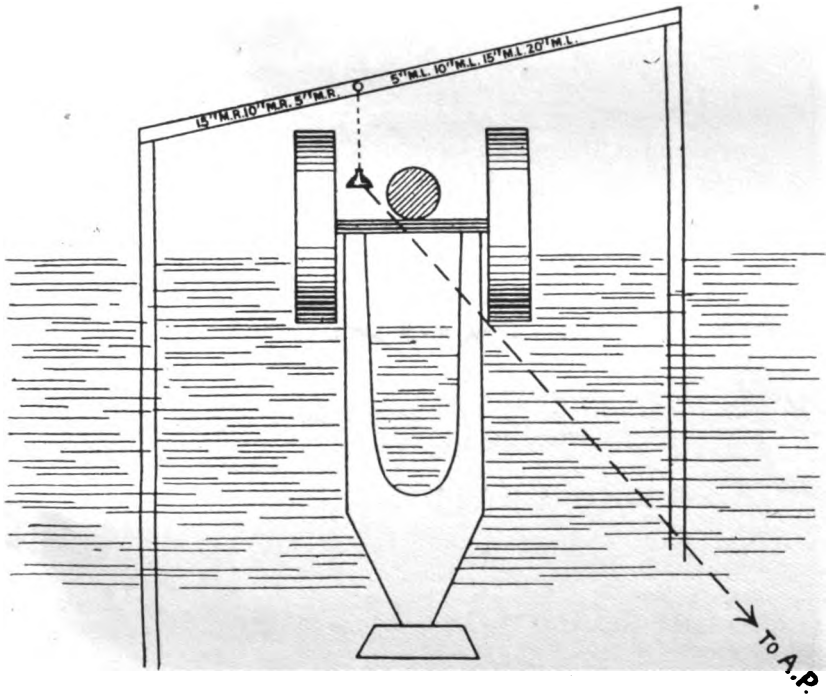
It is obvious that the displacement of the dial sight relative to an A.P. in direction of "A" is infinitely smaller than it would be relative to an A.P. in direction of "B". And with a steady platform and an A.P. 100ᵡ distant the error is negligible.

When we come to guns on road mountings or if platforms are not steady, the above will not suffice, and the following method is suggested as being simple and accurate:

A plank is fixed above the dial sight and with its longer axis at right angles to the line. Dial Sight—A.P. and the distance subtending an angle of 5 minutes at the A.P. is calculated. Say the



A.P. is 100ᵡ away, this distance then becomes 5 inches. When the zero line is registered, or preferably before firing at all, and with gun central on platform, the plank is graduated at 5 minute intervals, each interval being 5 inches, and marked; zero is straight above the Dial Sight and from zero to the right is marked 5′ M.L. 10′ M.L. &c., and from zero to the left is marked 5′ M.R., 10′ M.R. &c. When

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the gun is switched on to a target the No. 1 looks along the line from the A.P. and gives to the layer as a gun correction whatever deflection he reads above the dial sight, thus correcting for any lateral movement of gun or sight relative to the A.P.

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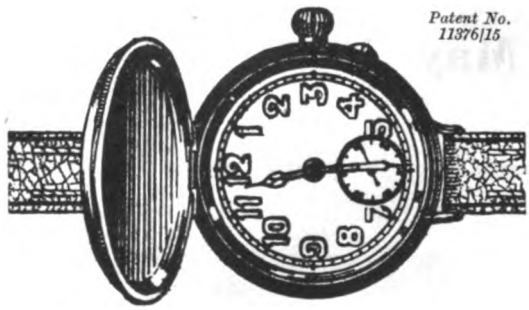

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FRIEDLAND, 1807.

Part I—"The Campaign 5-13 June, 1807."

Part II—Comments on the Campaign.

BY MAJOR A. F. BECKE, LATE R.F.A.

"Je réussissais dans ce que j'entreprenais, parce que je le voulais; mes volontés étaient fortes et mon caractère décidé. Je n'hésitais jamais; ce qui m'a donné de l'avantage sur tout le monde."

Napoléon.

Authorities consulted:—

"Correspondance de Napoléon* Ier (particularly Vol. 15); "Histoire des Campagnes de l'Empereur Napoléon, 1805-1809, (Paris, 1843); "Atlas des plus mémorables batailles, etc." by von Kausler; "Feldzüge in Europa seit 1792" by von Horsetzky; "Campaigns in Poland, 1806-7" (London, 1810) by Sir R. Wilson; "5-14 Juin 1807" by Lieut.-Colonel Michel; "Victoires, Conquêtes, etc. des Français" (Vol. 17); "Histoire et Tactique des trois Armes" (pp. 231-240) by Favé; "Champs de Bataille de l'Armée Française" (pp. 163-178) by C. Malo; "Cust's Wars of the 19th Century," Vol. II; "Grands Cavaliers du Premier Empire" by General Thoumas; "Grands Artilleurs" by Captain Girod de l'Ain; "Précis d'Histoire Militaire" (Part XII) by M. Dumolin; "Napoleon as a General" (Vol. I, pp. 342-373) by Count Yorck von Wartenburg.

The maps are based on:—Map of Poland in Sir R. Wilson's Account; Walker's Map of Poland, 1831; Europe, 1/1,000,000, Warsaw sheet, G.S.G.S. 2758, (1915); the 2 maps in Colonel Michel's account†; the map in von Horsetzky's Atlas; the map of the Battlefield published with Histoire des Campagnes, 1805-1809; and the Map in von Kausler's Atlas.

The Maps in Favé, in the Atlas published by Professor Woerl and von Dürrich (1857), and in the Atlas issued with Alison's Europe, appear to be reductions of von Kausler's Map.

* The only noteworthy documents in any of the *Correspondence Inédite* occur in Vol. I, 1804-1807, published officially by Picard & Tuetey.

† The positions of the troops on Maps 1 and 2 are based almost entirely on these maps.

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PART I.

THE CAMPAIGN.

GENERAL SITUATION.

TO appreciate Napoleon's great victory at Friedland it is necessary to realise the situation in which he stood at the opening of that campaign and the 10 days of manœuvres that preceded and led up to the decisive victory.

This campaign is really the final act of the war between France and the Allies (Prussia and Russia). The Emperor knocked out the Prussian and Saxon armies on the fields of Jéna, and Auerstädt (14 October 1806) and then proceeded to over-run Prussia, with the result that the country crumbled and fell. Napoleon at the head of the Grand Army then advanced into Poland in order to deal with the Russians and the small remnant of the Prussian Army that had evaded the opening *débâcle*.

The Russian advance in mid-January, 1807, finally terminated in the fierce, but inconclusive Battle of Eylau (7/8 February).

The waste of men and the exhaustion of the French depôts then required all Napoleon's energy and organizing ability to ensure their prompt replacement; meanwhile both armies rested for a time after their exertions.

Napoleon's situation was unenviable, he was a long way from France; Austria might seize the obvious opportunity and declare war to avenge Ulm and Austerlitz. He could not afford to advance far into Russia, and yet he must gain a decision as rapidly as possible. In his case the decisive pitched battle alone could shear through the Gordian knot of his difficulties.

Meanwhile, whilst repairing the wastage, the Emperor profitably spent the time in reducing the strong fortress of Danzig.[1]

To assist Russia and Prussia, Great Britain had agreed to send money, arms and ammunition, and also to disembark a force at the mouth of the Elbe to co-operate with the Swedes in Pomerania, whilst the Russians and Prussians attacked the French amies in front.[2]

Opposing Forces.

Russians. At the beginning of June the main Allied Army under Bennigsen was cantoned around the entrenched camp of Heilsberg, the available strength being about 120,000, well equipped with artillery. The distribution was broadly as follows:—

[1] It fell to Marshal Lefebvre on 27th May.

[2] Had the British Force landed whilst Danzig held out it might have achieved something of importance; but actually the first detachment did not land until after Peace had been signed at Tilsit, when it was quite powerless to do anything. "Wait and See," as a settled system of Policy, was as useless and dangerous to oppose to Napoleon as it has proved to be against Germany to-day.

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3 Divisions and 3 Divisions of Light Horse	30,000 under Bennigsen,[1] at Arnsdorf.	
2 Divisions	10,000 under Docktorov, opposite Wormditt.	
Corps	(8,000) of Gortschakov	South of Guttstadt
Corps	(8,000) of Platov	
Corps	(18,000) of Bagration	at Launau.
Guard	(13,000) Grand Duke Constantine	

Reserve, (10,000), under Kamenskoi at Lilienthal; Prussians, (15,000), under Lestocq, N.E. of Braunsberg; whilst Tuschkow (30,000) faced Masséna at Pultusk on the Narew, (30 miles N. of Warsaw). Also Reserves, (30.000), under Labanov were marching up to the Niemen.

French. Napoleon's Army available for immediate operations was about 150,000 strong, it was well found in every particular. Before the campaign opened it was disposed as follows:—

I. Corps	22,000 (38 guns, Senarmont)	Marshal[2] Bernadotte	On the Passarge from Braunsberg—Spanden;
IV. Corps	26,000 (55 guns, Dulauloy)	Marshal Soult	On the Passarge east of Liebstadt;
VI. Corps	17,000 (24 guns, Seroux)	Marshal Ney	Guttstadt and Wolfersdorff, across the Passarge;
III. Corps	25,000 (43 guns, Hannicoul)	Marshal Davout	At Allenstein; also on the Passarge, west of Allenstein, and back to Osterode.
Reserve Corps	19,000 (39 guns, Navelet)	Marshal Lannes	Marienburg;
VIII. Corps	13,000 (32 guns, Mossel)	Marshal Mortier	On lower Vistula;
Imperial Guard	10,000 (35 guns, La Riboisière	Marshal Bessières	Finkenstein;
Cavalry Reserve	21,000 (9 Divisions) (50 guns, Ruty)	Marshal Murat	Between Passarge and Vistula.

Imperial Head Quarters were at Finkenstein.

On the extreme right was the V. Corps, 26,000, Marshal Masséna — Covering Warsaw and observing Tuschkow on the Narew.[3]

General Victor and a Hessian Division (7,000) were employed on the siege of Graudenz.

As well as the above army, Brune was coming up with 15,000 men from Holland, 14,000 Spaniards were marching to the Elbe and the Divisions of Boudet (8,000) and Molitor (9,000) had entered

[1] General Bennigsen the Allied Commander-in-Chief was 62 years old and apparently in very poor health (*Dumolin, p. 587.*)

[2] Bernadotte was wounded at Spanden on June 6th; General Dupont took over temporarily, and General Victor was then appointed to command the I. Corps. (Letter of General Senarmont, 7th June; Also Napoleon's urgent letter to Victor to come to Finkenstein, (*Corr. 12734*). General Victor became a Marshal in July 1807.

[3] The numbers are based on Dumoulin pp. 578, 579. Tuschkow was succeeded by Tolstoi.

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Germany. In Silesia 15,000 Würtembergers were available if required, and if necessary 10,000 men could be spared from the garrisons in Germany.[1]

The actual field army available in the theatre of operations was covered by 3 Corps (vide Map I)—I, IV. and VI—along the line of the Passarge. These corps had strengthened the points, where serious resistance was to be offered, by works and abatis; owing to these strengthened positions and that they would co-operate with one another, these covering corps ought to be capable of forcing an enemy to deploy and show his strength and then be able to hold at bay very superior forces for at least 24 hours; and a mere glance at the map will show that by the time the retreat was a day old Napoleon could mass the Grand Army and be ready to strike a blow that would decide the campaign.

Also it is apparent from the Map that Ney being the most exposed of the 3 covering corps was naturally kept the most concentrated.

The numerical superiority of the French was so very marked that, after Eylau, Napoleon opened overtures for peace, which he repeated in April. This was done entirely with the idea of emboldening the Russians, so that they might be induced to attack and give Napoleon the chance to destroy their Army and finish the campaign. However by June, after Danzig had fallen, it appeared that Napoleon would have to advance on Bennigsen and seek the decisive battle that he desired so earnestly; indeed his plan was to open operations on June 10,[2] when most unwisely Bennigsen opened the offensive. Napoleon apparently had intended to capture Königsberg and seizing the first chance of a general action throw the enemy back on the Niemen. Had the Russians refused to fight a pitched battle to cover Köngisberg, awaited Napoleon on the Pregel, delayed him there with rearguards, and fallen back behind the Niemen, they would have secured concentration with their reserves, drawn the French further from their resources and made Napoleon's position extremely precarious.

Bennigsen's Opening Manœuvres.

Whilst Danzig's fate was in the balance the Russians had been concentrated round Heilsberg, but now when they desired to open the offensive on June 5th they spread themselves out thinly and advanced in no less than 7 columns against the French covering corps. The unwisdom of their procedure is quite clear and Bennigsen must have been disappointed with the result of his manœuvre. Apparently his plan was to converge 2 of his columns against Ney's Corps, a plan that was too complicated to be likely to fulfil the expectations he had formed of it.

---

[1] The total French Army under arms at this period in all districts, including France, numbered 700,000 men. Dumoulin, p. 580.

[2] Corr. 12728 and 12731. Also letter to Berthier, 5 June, directing him to order the Corps Commanders to be ready to move on June 10. Each Corps was to have with it ten days' supplies. (*Correspondance Inédite*, 1804-1807).

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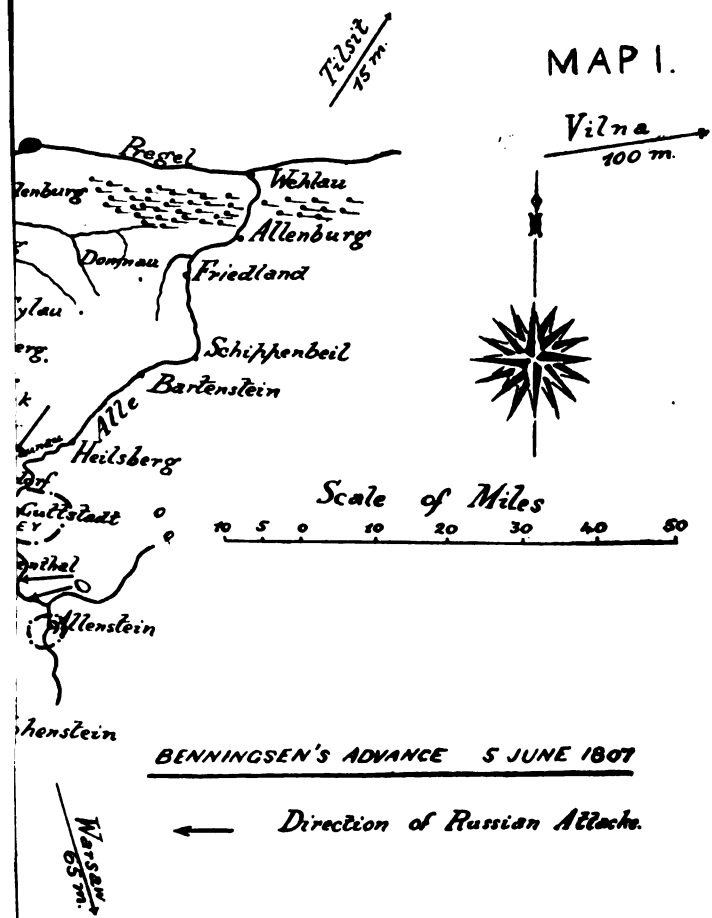

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But Ney was not surprised, and he extricated his corps before the columns closed. Bennigsen's failure proves once more that it is only possible to manœuvre around a fixed point.

When the Russian advance was first reported to the Emperor[1] he ordered that, if pressed by serious forces, Ney should fall back slowly and in good order between Soult and Davout, who were directed to cover his flanks.[2]

So sure was the Emperor of the ultimate outcome of the operations that in a letter to Cambacérès (6th June) there is this sentence, "My reserves are moving up and when you read this great things will have happened."[3] In a letter of the same date (6th) to Fouché there occurred an even more striking forcast . . . "Eight days after you receive this letter all will be finished . . . ."[4]

Whilst the covering corps fell back slowly and fighting a yielding fight to gain the time and the space for concentration, Napoleon massed the Army at Saalfeld so as to be ready to strike into Bennigsen's flanks, either if he turned against Soult or if he attempted to pass on and seize Thorn on the supposed French line of operations.[5] Early on June 7th the Emperor would be ready to strike according to whatever might then be the situation.

The ground over which he had to conduct his retirement was all in Ney's favour, being wooded and covered with lakes; consequently the Russians were unable to deploy their forces and make their numerical strength felt; and had Napoleon's plans worked out even approximately as he desired them to do then it mattered little if they advanced on Thorn or swung against Soult; for the French concentration once completed they were bound to meet with a swift disaster.

But Ney had not been admitted into Napoleon's confidence and not unnaturally he did not grasp the full significance of the plan;[6] and having drawn on Bennigsen on June 5th in the most admirable way, on June 6th he elected to offer much more serious resistance. By most skilful dispositions he held up Bennigsen's 50,000 with his 17,000 and only yielded 4 miles of ground during that long midsummer day. His rearguard tactics, both dispositions and manœuvres, were masterly; but the essential was to draw on Bennigsen and immobilize him, and not to keep him back or give him any inkling of what was afoot.

---

[1] Ney's report, stating that his advanced troops had been attacked, reached Finkenstein at 2 p.m. having taken only 7 hours coming from Guttstadt over 45 miles away. To-day it would have been a question of minutes, but in 1807 the Emporer arranged relays for forwarding dispatches expeditiously from his covering corps.

[2] Corr. 12730 and 12731.

[3] Corr. 12732.

[4] Corr. 12733. On June 19 he wrote to the Empress from Tilsit (Corr. 12771) and was able to say . . . . "La bataille de Friedland a décidé de tout" . . . . Few predictions have had a more remarkable fulfilment.

[5] As a matter of fact when Danzig fell the French line of operations was changed to run via—Marienwerder—Marienburg—Danzig. Letter to Davout, 6th June. Corr. 12741).

[6] Nor did he on June 16 and 17, 1815, but then with far less excuse; for in 1815 Napoleon had written a special letter for his guidance. (Corr. 22058).

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Bennigsen was further warned and discouraged by Davout, who had failed equally to appreciate Napoleon's plan. The Marshal, considering that Ney was in a tight corner, tried to relieve the pressure by a strategem instead of drawing on Bennigsen towards Thorn by the use of yielding tactics.

Davout, who had concentrated the III Corps, sent Ney a message stating that if Bennigsen pursued any further, then he would find 40,000 men descend across his rear. The despatch was handed to a selected cavalry officer who was told to follow a certain road that must ensure his capture. He was taken prisoner that day (6 June) and this despatch and Ney's stubborn resistance caused Bennigsen to curtail his advance and that undoubtedly saved the Russian army.[1]

The result of the ruse was most disastrous, but there is no doubt that the mistakes made by Ney and Davout were due entirely to the fact that they had not been informed and had not recognised the essential in Napoleon's plan.

Bennigsen Retires. The Action at Heilsberg.

Bennigsen, on receipt of Davout's false despatch and in face of Ney's increased resistance, considered it would be unwise to risk a pitched battle and withdrawing, on June 9th, he returned to Heilsberg. The entrenched camp at Heilsberg lay astride the Alle, 5 bridges having been thrown to connect the two banks. Napoleon followed across the Passarge, heading for Guttstadt, and by the evening of the same day Murat and 5 cavalry divisions followed by Ney, Lannes and the Guard had reached the place, whilst Soult and Davout were within a day's march. The Grand Army now being well in hand, the Emperor determined to attack Bennigsen at Heilsberg on the morrow. Consequently on June 10th Murat, Soult, and 1 Division of Lannes' Corps assailed Bennigsen's position; however at the end of the day, after fairly heavy fighting,[2] the result was clearly inconclusive; but Bennigsen, far from being ready to profit from such success as he had achieved, began to be nervous about his connection with Königsberg, consequently on the next day (June 11th), as Davout's Corps had moved between Heilsberg and Königsberg, he prepared to open his retirement and by nightfall the place was evacuated and the Russian Army moved North along the right bank of the Alle.

Kamenskoi and 2 Divisions (10,000) were detached at 6 p.m. from Bartenstein to move directly to Königsberg, and cover the place,

[1] No doubt Davout had recalled an incident of the Eylau Campaign, when the Russian Cossacks captured, on a young French Officer, Napoleon's plan of campaign (Jany. 31) which was being taken to Bernadotte. This captured despatch opened Bennigsen's eyes to the danger he was running and he drew back in time. Davout thought he might repeat the procedure.

[2] The French lost about 2,000 killed (including General Roussel) and about 8,000 wounded (including Generals Espagne, Ferey, and Viviès); Soult's Corps alone lost over 6,500. The Russian losses appear to have been about 3,000 killed (including 2 Generals) and about 9,000 wounded (including 13 Generals).

General Espagne in the last charge against the Cavalry of the Russian Guard received 7 wounds from a lance and had his horse killed under him; his division was decimated in the hard fighting on this day. General Espagne was killed in the Battle of Essling (1809); born the same year as Napoleon, he died in the same battle as Lannes; fortunate in the time of their death, for still victory crowned the eagles of the Grand Army and Napoleon was still all-powerful.

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acting in co-operation with Lestocq.[1] This detachment reduced Bennigsen's army to about 60,000 men. Kamenskoi, by making a detour, managed to avoid colliding with Davout's advance and he got away along the Königsberg road. Bennigsen had merely weakened himself by making a useless detachment. "March together! Strike together!" was a fairly safe maxim to adopt under like curcumstances.

Napoleon advances to force Bennigsen to fight.

On June 11th Napoleon collected his troops and he entered Heilsberg after the Russians vacated it; by the evening of June 12th the French Army was well in hand and ready for any eventuality. On the next day (13), 3 Divisions of cavalry, Ney, Mortier, Victor and the Guard continued to move along the left bank towards Eylau, being thus between Bennigsen and Königsberg and ready to engage and deal a knock-out blow directly the chance presented itself. Whilst on June 12th, Latour Maubourg had been ordered with his Dragoon division and two light cavalry brigades (detached from Lasalle's Division) to follow Bennigsen down the right bank of the Alle. More significant still, Murat was ordered that if Bennigsen advanced on Domnau on June 13th he would leave Marshal Davout to attack the head of Bennigsen's advance,[2] whilst it was attacked in flank by the mass of the Grand Army striking North from Eylau. (Vide Map 2).

Early in the afternoon of June 13th Napoleon received definite news that the Russians had passed Schippenbeil and he then considered that they might not cross the Alle. Previously orders had been issued to Soult in case it became necessary to pursue Bennigsen to the Pregel;[3] and Murat was now ordered to have boats collected on the Pregel to assist his passage of that river, if the Königsberg bridge head could not be seized.[4]

Bennigsen seizes Friedland. Napoleon reaches the place.

By the evening of this day Napoleon learned that the Russians held Friedland; but he considered that this was merely a precautionary move, to prevent him striking at Bennigsen in his retreat past the place; he did not think it could mean that the Russians after all were crossing to the left bank.

Lannes' cavalry had reported the presence of Russian cavalry patrols at Georgenau (4 miles W. of Friedland), and at 9 p.m. a further report came to Imperial Headquarters that Lannes' advanced cavalry Regiment (9th Hussars) had occupied Friedland, but at 6 p.m. it had been driven out by about 3000 Russian horse.

To be ready for any emergency, Napoleon set the Grand Army in movement, and at 1 a.m. on June 14th Mortier, Grouchy, Ney, and Nansouty were all marching northwards. At and around Eylau he

[1] It seems that Bennigsen had formal orders from the Czar to cover Königsberg, and also he does appear not to have relished the idea of abandoning Prussia entirely. Königsberg was unready in every way and Bennigsen should have withdrawn all his forces and got clean out of touch now that Napoleon had concentrated the Grand Army and advanced seeking for a battle. Only by keeping the Russian army intact and waiting until it was heavily reinforced could Bennigsen hope to achieve anything; and the sacrifice of Königsberg was nothing if it proved to be the price of ultimate victory.

[2] Corr. 12749. [3] Corr. 12750. [4] Corr. 12752.

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kept in hand the Guard and Victor and the Cavalry Divisions of Latour Maubourg[1] and La Houssaye. By 4 a.m. on the 14th Napoleon started these troops, and left himself for Posthenen (2 miles W. of Friedland).

By 11 p.m. on June 13th Lannes had sent Oudinot's Grenadiers to Georgenau to support his cavalry and had ordered up his other division (Verdier).

General Oudinot[2] (serving under Marshal Lannes, but having the privilege of reporting direct to the Emperor) sent six of his aides-de-camp to report that, from the General's own personal reconnaissance, he was convinced that the whole Russian Army was in Friedland. Some time later Marshal Lannes having taken over the command on the field sent one of his own gallopers, saying to him, "Ride your horse to death Saint Mars, to reach the Emperor the quicker, and tell him we have the whole Russian army on our hands." Saint Mars carried the order without sparing his mount. The Emperor received him, amidst his staff, and walking his horse alongside the A.D.C. made him recount in detail the events of that morning, the terrain and the positions of the opposing forces. Napoleon and his staff then galloped forward heading for the battlefield.

But it was not until the Emperor actually reached the field about noon on June 14th and made his own reconnaissance that he was finally convinced that the Russian Army had crossed to the left bank and the battle he had longed for so ardently could be fought then and there.

Arrangements for the Decisive Battle.

Murat was now ordered[3] to leave Soult and a division of cavalry to secure Königsberg, if it had already been seized, and with Davout and two Cuirassier Divisions[4] to hasten to Friedland, as it was possible the battle might continue until June 15th. Napoleon even suggested that perhaps he would merely amuse Bennigsen that afternoon with a bombardment and await Murat's arrival on June 15th before he gave the Russian Army its death-thrust. However, after further reconnaissance revealed fully to him the dangerous situation in which Bennigsen had placed the Russian Army, he decided to engage it immediately and to destroy it that evening; otherwise it might use the night to escape from certain destruction on the morrow. Then in a flash he decided on his plan of action and immediately issued the well known order[5] to his Corps Commanders which gave to the Battle its definite form and turned it into a masterpiece worthy to rank with Marengo, with Jéna, and with Austerlitz.

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[1] Latour Maubourg had been ordered to cross the Alle at Bartenstein and move to Domnau.

[2] Oudinot became a Marshal in July 1809.

[3] "Before Friedland, 3 p.m., 14 June." This letter is not in the Correspondance, but is given by General Michel, pp. 37-38.

[4] Those of Espagne (now General Reynaud) and Saint-Sulpice. Espagne's Division was not present at the Battle of Friedland, as many writers aver; it accompanied Murat.

[5] Vide Appendix B; Corr. 12756.

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PART II.

COMMENTS ON THE CAMPAIGN.

The campaign (June 6-14) clearly divides itself into two parts which are separated by the Action of Heilsberg (June 10) and completed by the Battle of Friedland (June 14).

At the commencement of the 1st part the Grand Army lay in its cantonments (*vide* Map I) being covered by the Corps of Bernadotte, Soult and Ney along the Passarge, and although many writers have affirmed that it was surprised by Bennigsen's attack, yet we agree with General Michel that within 48 hours the Grand Army was ready to fight a big battle. Napoleon's *couverture* had achieved much of what he demanded of it.

This result, as General Michel points out,[1] was obtained by the way in which the covering corps were handled. By their resistance they gained for the Emperor the time and space in which to concentrate his army.

But the essential duty devolving on Bernadotte, Soult and Ney was clear, they had to draw on the Russians without getting closely and inextricably engaged with them; and yet they had to be prepared to take the offensive at a moment's notice, should Bennigsen's pursuit show signs of dying out, and then grip him at once, tearing aside any screen he might have left behind.

As a study illustrating the correct way to cover an army, that desires above all else to fight an immediate pitched battle; and the possibilities that will arise, if the covering corps are skilfully and correctly handled, Napoleon's arrangements on the Passarge are an example worthy of the closest study.

It was unfortunate that neither Ney nor Davout were fully in the Emperor's confidence. Had they been so they would have recognised that not only was time and space to be gained for the concentration of the Grand Army, but Bennigsen was to be drawn on and immobilized ready for the stroke that the *Masse de Manœuvre* (or Reserve) would be ready to deal him on the third day. In that case Ney would have continued retiring slowly, thus drawing on Bennigsen between Davout and Soult, whilst the Cavalry Reserve would have massed with Soult ready to cut in on Bennigsen's open right and rear directly the Corps in Reserve had come up and engaged the Russian Army. But not realising clearly how the Emperor meant to bring on the decisive pitched battle, Marshal Ney merely aimed at gaining time for the concentration and so used the most skilful rear guard tactics to cause the Russians the utmost delay; whilst Marshal Davout by his ruse deterred Bennigsen from following up an apparent success and was one of the real causes for his sudden retirement to Heilsberg just when the Emperor was ready to commence a decisive manœuvre.

Another point that requires alluding to is the position of the Cavalry Reserve. It was disposed in extended cantonments behind the centre of the line, where it was available to act as a large mobile

[1] Pages 8 and 9.

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reserve, thus allowing Napoleon, within 48 hours, to mass 20,000 sabres at any threatened point; and it is clear this time would be gained by the action of the covering corps.

Despite the fact that at the present time the pursuing Infantry can be brought rapidly to the front in motor transport yet the task of the Covering Corps to-day appears to be easier than it was in the Napoleonic times—owing to the introduction of air-craft, the improvements in modern weapons and propellants and the fact that cavalry are now the ideal mounted riflemen, who can fight indifferently on horseback or on foot. In the Napoleonic times, owing partly to the restricted ranges of firearms, actions opened and became critical at almost the same moment; this makes Marshal Ney's success the more striking. To-day the resistance can usually be offered at long and medium ranges and when the enemy finally reaches assaulting distance probably the rearguard has long since slipped away.

The distribution of the French Corps on and behind the Passarge is also instructive because it illustrates Napoleon's ideas of defending a riverline.[1] The Emperor whilst at S. Helena stated: "Nothing was more correctly planned . . . . than the defensive position on the Passarge in 1807 to cover the siege of Danzig." Writing to Bernadotte on 6th March 1807[2] he said, "A river or any line can only be defended by occupying some offensive points; for if one has done nothing but defend oneself one has run risks without having gained any results whatever; but if the defence can be combined with an offensive movement then the enemy will have to run greater risks than the corps attacked." It was to carry out this principle that Napoleon ordered the covering corps along the Passarge to construct bridge heads so that they might be able to operate and strike on the further bank; because having a hold on that bank they would be ready to move across directly the opportunity offered or the necessity arose. The Emperor's opinion was undoubtedly confirmed by what happened in 1807, for he wrote in the next year,[3] "no river, be it as wide as the Vistula or as swift as the Danube near its mouth, is any obstacle provided one has free access to the far bank and one is always ready to assume the offensive." Compared with the Vistula and Danube the Passarge was a mere ditch.

To stand on the defensive behind a river line must be a most dangerous proceeding, because if the enemy forces a passage by surprise, and the teaching of history is clear that he does always force it, then the defending army is generally in a very extended position and the assailant should be able to prevent it effecting a concentration. Consequently if it is intended to limit the army altogether to the defensive then the troops must be so disposed that they can be massed and fall upon the foe before he can complete his passage of the river. This should be an easier feat to-day, aided by modern means of reconnaissance and of communication. The dispositions on the Passarge were such that a grip was kept on the far bank by means of the bridge heads, and the dispositions of the corps was arranged in such a way that they could be concentrated

[1] Vide "Napoleon as a General," i, 354-356.

[2] Corr. 11961. [3] Corr. 14283.

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for certain and in time to crush any offensive by Bennigsen's main army.

In the second period the Emperor retook the offensive pure and simple. Bennigsen having fallen back on Heilsberg accepted an action there in which his army was by no means worsted; but then the mere threat of cutting his connection with Königsberg sufficed to cause him to retire hurriedly along the right bank of the Alle. Napoleon then left the Russians to carry out the retirement down the Alle whilst he pushed on towards Königsberg; but his objective was no mere geographical point. Summing up his opponent accurately he realised that to threaten Königsberg was the surest way to force the unbeaten Russian Army to cross the Alle, then it would be within his reach and it could be forced to deliver a pitched battle. With much the same idea he had directed his march on Berlin in October 1806 at the opening of the campaign against Prussia. Now, leaving Latour Maubourg and his Dragoons to follow the retiring Russian Army, the rest of the Grand Army moved to Eylau and massed there (vide Map 2), merely waiting to bound at Bennigsen's throat the moment he had crossed to the left bank.

It would have been playing the Russian game after Heilsberg if Napoleon had opened the direct pursuit along the right bank of the Alle; for a stern chase is proverbially a long chase and Bennigsen must have retired behind the Pregel without delivering the pitched battle that Napoleon needed so sorely.

The Emperor had noted the effect on Bennigsen of the mere threat of Davout's corps; and summing up his adversary at once he decided to follow him only with some cavalry and to concentrate the rest of the Grand Army at Eylau.

By this manœuvre he felt certain that he could draw his adversary across the Alle; and as there were only 3 available bridges—at Bartenstein, Schippenbeil and Friedland—the reason for the selection of Eylau is quite clear, for it covers all three passages.

As the Emperor required the decisive battle so earnestly it is necessary to consider why he detached towards Königsberg a force of over 50,000 men—Soult, Davout and two Divisions of the Cavalry Reserve. It has been considered that this detachment was extremely unwise at a moment when the heads of the Russian columns might be seen crossing to the left bank; nor was the cavalry needed to reduce Königsberg, because all history shows that fortresses fall like ripe plums to the conqueror in the field.

After the indecisive action at Heilsberg Napoleon was more than ever determined to force a decision, and as we know massed at Eylau, so as to be between Bennigsen and Lestocq and Königsberg. It is easy to judge after the event; but although it appeared certain that Bennigsen would be drawn to the left bank it was impossible to know where the battle would take place; and in order to safeguard himself the Emperor pushed out suitable detachments towards the different objectives, to cover him whilst he struck the knock-out blow.

If Bennigsen crossed the Alle Napoleon wished to be free to attack him and drive him back on the swampy forest tract to the North, and pursuing to the Pregel not a Russian gun or man would

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have got away. To carry out this stroke, with the necessary rapidity, the Grand Army must be protected on the Königsberg side; also Bennigsen's advance Westward must be held up until Napoleon could engage the bulk of the Grand Army. As, early on the 13th, the leading troops were too far South of Domnau to head off Bennigsen if he crossed at Schippenbeil, this task was to devolve on Murat and Davout, whilst Soult neutralized Lestocq. For this double purpose the detachment had to be a strong one.

On the other hand if Bennigsen retired down the Right Bank and crossed behind the Pregel, then, having rushed Königsberg, Murat could pass through and up the right bank of the Pregel and be able to strike Bennigsen's left (or Western) flank whilst Napoleon, after crossing the Alle at Friedland, pressed the direct pursuit. To rush Königsberg and catch up Bennigsen, if he adopted the sound course, required considerable forces and a fairly numerous cavalry, accounting fully for the strength of Murat's detachment. Napoleon forsaw everything, and he did not base his plan of campaign on the single assumption that the enemy would make an egregious blunder; for he arranged his army so that, with no adaptation, it would be equally effective even if the enemy adopted the sound course. It was not the Emperor's custom to leave things to chance.

On June 13th Murat and Davout were not half a day's march from Marshal Lannes, therefore they were available for a big battle on the Alle's left bank, and only Marshal Soult could not have co-operated directly. But Soult's Corps was the smallest force capable of neutralising the 25,000 men under Lestocq and Kamenskoi and also the garrison of Königsberg.

The Emperor fully understood the importance of Economy of Force and rarely has he given a finer illustration of this principle.

Considered seriously with the idea of appreciating his handling of his Army before and during the campaign, the information he possessed at the time and the reasons that underlay his manœuvres, it is no exaggeration to say that the manœuvres that brought on the decisive battle of Friedland are one of the finest expositions of offensive strategy which are recorded in History.

Also a study of the operations show that, when considering a plan of campaign, Napoleon made no attempt to make a precise forecast of what his operations would be after the first tactical encounter. Rather he fixed his mind on the essential object that he was determined to attain; and then, when the campaign opened, he carried out his strategical concentration so as to place the Grand Army in the best possible position to attain that essential object. Once the operations had commenced, he never hesitated; but calm in mind and inflexible of purpose he led the Grand Army forward until, as a result of his manœuvres, the wished for opportunity arrived, when he struck the blow that finished the War. Those writers who desire to criticise Napoleon's handling of the Grand Army in this great campaign assuredly employ themselves on the profitless task of champing their teeth upon a granite block.

(To be continued).

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METHOD OF CORRECTING ERROR

Introduced by use of near Auxiliary Aiming Post.

BY 2ND LIEUT. J. N. KENNEDY, M.C., R.G.A.

THE following method is suggested as a means of compensating for the error introduced when laying on auxiliary aiming points or pickets which are close to the battery position.

This condition is a common one, since near aiming points must of necessity be adopted.

(a). In foggy weather.

(b). At night.

(c). When the view of the layer is limited by the configuration of the ground.

The error under consideration may be a very large one. For instance, with an aiming point 60 yds. distant in rear, a side jump of the gun across the platform of one yard would cause an error of 1°, which at a range of 6000 yds. would represent 100 yds., and at 9000 yds., 150 yds. At present no means are taken to eliminate this inaccuracy.

Proposed method of correction.

A second picket is planted in line with the picket which is to be used as an A.A.P., and exactly half way between it and the gun.

If the gun jumps on firing, the two pickets will cease to be in line. The gun is now re-layed on the A.A.P., then the oscillating scale is moved until the sight is layed on the nearer picket.

The error will now have been taken up on the oscillating scale, and when the gun is re-layed on the A.A.P. the line of fire will automatically have been corrected.

If it is desired to correct again, the oscillating scale is brought back to zero, or to the reading originally ordered for parallelism, concentration, etc. (This will of course vary according to the methods employed by the particular battery), and the procedure detailed above repeated.

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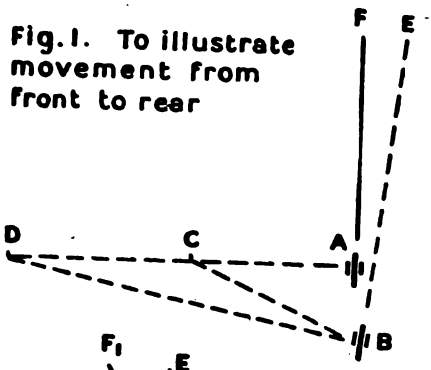
EXPLANATION OF PRINCIPLE

Fig. 1. To illustrate movement from front to rear



D Picket used as A.A.P.

C Picket planted half-way between A.A.P. and Gun.

A Gun 1st position. B Gun 2nd position after jump.

A F is line of fire.

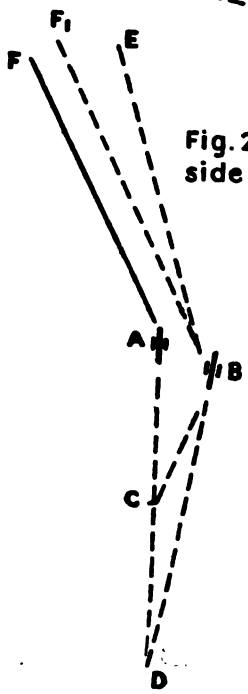


Fig. 2. To illustrate side jump.

In Fig. 2, BF is a line parallel to AF through 2nd position of gun DC = CA = CB (approx.).

If, after jump gun were to lay on D with same angle as when at A the line of fire would be, in this case, BE which is too far to the right the amount of error being ∠ FBE (∠ F,BE in Fig 2), which is equal to ∠ ADB for,

$$\angle ABD + \angle FBE = \angle DBE = \angle DAF = \angle ABD + \angle ADB$$

$$\therefore \angle ADB = \angle FBE$$

and since CD = CB

$$\angle ADB = \angle CBD$$

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Moving the oscillating sight from D to C (i.e. from left to right) would automatically give a *left* correction equal to $\angle$ CBD, which is what we require. Leaving the oscillating scale at this correction the gun is once more layed on D.

NOTE.—The pickets would of course be aligned in the first place when the line of fire is originally laid out, or when the gun is firing accurately on a known point.

At night when lamps are used, it would be preferable to use lamps of different colours. For night firing the correction ought to be adjusted at frequent intervals, as the gun is always changing its position on the platform.

Of course when A.A.P. is to a flank, side jump is negligible and when A.A.P. is to the rear, movement along Line of Fire is negligable, as the point of impact would theoretically be altered only by the actual amount of the jump in yards.

It may be urged that this method is not strictly accurate, for Δ DCB will not always be an iscoceles triangle. The error introduced on this account, however, is infinitesimal. It is a matter of no great difficulty to devise a method which would be absolutely free from error, but the all-important advantage of simplicity and practical utility in the field would be sacrificed.

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WIND PLOTTER.

By 2nd Lieut. G. L. Norsworthy, R.G.A. (T.F.).

EXPERIENCE in the field shows that much time is often lost (especially when two or three targets have to be engaged at the same time and wind corrections have to be worked out for each one) by having to calculate these corrections. I have therefore designed a Wind Plotter which does away with *all* calculations, and so reduces any possible error to a minimum and at the same time enables deflection and range corrections to be ascertained in a very few seconds.

The outer ring **A** drawn on a card is marked every 10° from 0°—360°. The shaded disc **B** is pivoted centrally so that it can be slipped on and off. The pointer **C** is also pivoted at the same point.

On the shaded disc are six rings. On the smallest are figures for 6000ˣ, the next is for 7000ˣ and so on up to 10,000ˣ. The inside figures on each ring are for range, the outer ones for deflection. For ranges lower than 6000ˣ more rings can be added if necessary.

Thick deflection figures denote ... ... minutes left.

Thin deflection figures denote ... ... minutes right.

Thick Range figures denote ... ... yards minus.

Thin Range figures denote ... ... yards plus.

The disc on the diagram is made out for a wind of 30 f.s. and for use in my battery I have made discs for every 5 f.s. from 5 f.s. to 60 f.s. As soon as a meteor weather report comes in I slip on the correct speed card.

To use Plotter.

Say line of fire is 90° TN. Wind 30 f.s. at 300°. Range 8000ˣ. Set arrow **D** to 90° on outer ring **A**. Set edge of pointer **C** to 300° and against the edge read figures on the 8000ˣ range ring which in this case are 20′ left and—145 range.

The figures are taken from the range table of our gun which are given for a wind of 30 f.s. It is easy to make the necessary calculations for other wind speeds.

The diameter of my plotter is 9 inches, which is a convenient size unless more than six rings are required.

I have made the pointer **C** out of a strip of celluloid.

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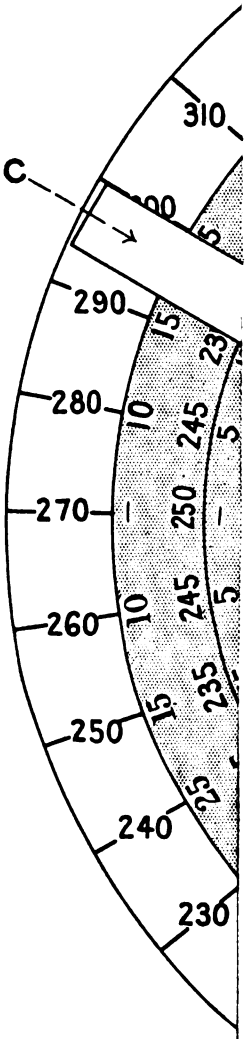
Issued with the

Upper figures = De
Lower figures = Ra



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THE MINOR CAMPAIGN IN EAST AFRICA."

A Lecture delivered at the Royal Artillery Institution, Thursday, 29th March, 1917. (Illustrated by Lantern slides).

BY MAJOR G. P. A. PHILLIPS, R.E. (R. of O.).

Brig.-Genl. W. F. Cleeve, C.B., R.A.,
Commandant R.M. Academy, in the Chair.

THE CHAIRMAN: Ladies and Gentlemen: I have pleasure in introducing to you the Lecturer, Major Phillips, who is going to give us a Lecture on The Minor Campaign in East Africa. I do not think many of us know very much about it, and certainly not about the earlier part of it. I am sure we shall be very glad to hear it.

MAJOR PHILLIPS: General Cleeve, ladies and gentlemen: If proofs were required as to the facts of Germany's agressiveness and preparation for this great war, we have only to turn to the numerous minor campaigns which have been and are being fought outside Europe—practically throughout the world, except in South America. Even there two of the most interesting naval actions have been fought out, namely off Coronel and the Falkland Islands.

The campaign in East Africa is only one of about thirty-seven campaigns and rebellions which have been stirred up by the really wonderful ramifications of Germany's secret service agents. British troops have taken part in no less than twenty-eight of them; in four of these the assistance of allied troops was invoked, namely, in Togoland, Cameroon, East Africa and the capture of Tsin-tau.

It was evidently Germany's intention to set the whole of Africa in a blaze and a glance at the map will solve the meaning of this effort. Africa bars the way to the Indian Ocean and the Far East. There are only two roads at present by which commerce can be economically carried between Europe and the Far East; one lies along the North of Africa through the Suez Canal and Red Sea, the other takes a longer but cheaper route round the Cape of Good Hope. It was against these two great highways of British trade that Germany made her greatest efforts. Incidentally it is interesting to note that Germany has been assiduously developing two alternative routes to the East, one to the North of Africa via the Baghdad Railway, the other, not so obvious, but possessing very great possibilities, lies across the Continent of Africa from Lobito Bay, near Benguela in Portuguese Angola, through the Southern position of Belgian Congo to Lake Tanganyika, thence to Dar-es-Salaam on the Indian Ocean. This route lies almost entirely on healthy uplands suitable for white

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people and only requires a few hundred miles of rail to complete it. Germany has made no less than four diplomatic efforts to get possession of Portuguese Angola, doubtless with this object in view.

One has only to consider for a moment what a difference it would have made to the general situation in Africa if Germany had possessed Portuguese Angola and the Belgian Congo, or even such portions of the latter as would connect Cameroon and S.W. Africa with East Africa. Instead of three separate campaigns in each of which the Germans were isolated and defeated in succession by the convergence of several columns, the problem would have been complicated by the ability of the Germans to make the most of interior lines.

To realise the importance of East Africa to Germany it is necessary to note that her only possessions further East were on the Western side of the Pacific Ocean, namely—the North East part of New Guinea and several groups of Islands lying between Samoa and the fortress of Tsin-tau. The nearest supporting point or stepping stone to these is East Africa, hence Germany's continued effort to retain even a small portion of it, even if only a small 'window' looking towards the East.

The campaign which has been and is still being fought in this part of the world is of exceptional interest and would have been considered one of the most important "small wars" in history had it not been overshadowed by the greater events in Europe and had not other minor campaigns distracted attention.

Many lessons in the conduct of a small war under special conditions may be learned from it. Amongst these may be mentioned the following points:—

Strategically—There is the want of any clear or well defined objective except the enemy's main field force, which had exceptional qualities seldom met with in a small war—regular organisation and a system of warfare very closely approaching regular warfare. Considerable division of force was necessitated to advance into the enemy's territory. The reciprocating action and co-operation between the two most important columns invading from the North on parallel lines, carried out with almost mechanical method is most interesting. The changes of base Southwards along the coast as the columns advanced adds one more example of the great value of the command of the sea.

Tactically—There is the interesting psychological factor of native troops facing shrapnel and machine guns for the first time; the value of wide turning movements rendered possible by the nature of the country and the employment of considerable numbers of mounted troops; also the very great difficulties of carrying out the deliberate attack by fairly large bodies of troops in dense tropical bush, where artillery could render little or no support.

The question of transport—was presented in a new aspect; the value, possibilities, and limitations of mechanical transport in a roadless country, covered in part by dense tropical forest, and with great distances to traverse.

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These points and the campaign as a whole, cannot be fully appreciated without some knowledge of the military geography of the area of operations, but time only permits of a very brief and general summary of this important matter.

From a study of the map and the scale of miles marked on it, the immense area over which the operations were conducted gradually impresses itself. Here is an area of 384,000 square miles, or nearly twice the area of Germany itself, containing a population of over 8 millions.

The length of the diagonal from N.W. to S.E. is about 1,000 miles. The land frontiers alone measure over 2,200 miles of which the northern portion, where British East Africa and Uganda touched German territory, is over 600 miles.

The intervening waters of Victoria Nyanza, measure about 175 miles across. The lake itself has an area about equal to that of Scotland. On the West, Belgian Congo either touches or is only separated by 30 to 40 miles of water, for over 500 miles; thence North-East Rhodesia, British Nyasaland and Portuguese East Africa close in the S.W. and S. frontiers. The coast line is about 450 miles long measured in a straight line.

The lakes constitute a distinctive feature from a military point of view as they involved small "Over-sea" expeditions of an interesting nature. With the exception of the great Lakes between Canada and the United States, this is the only frontier in the world which includes a chain of Lakes. The longest, Tanganyika, stretches North and South for 400 miles, or the distance between London and Aberdeen, but it is only 30 to 40 miles broad. Its side margins are sheer walls of rock making it very inaccessible. At a few points only can it be reached through gaps in the hills, notably at Ujiji-Kigoma, on the East where a river flows into the lake, and at Lukuga on the West where the Lukuga River carries off the surplus water of the lake into the Congo River system.

From the rails and roads shown on the map much may be deduced as to the real intentions of the German Government with regard to its future policy in connection with its neighbours—whether friendly, and with the object of working amicably together, co-operating for the mutual benefit, or otherwise. The trend of the rails and the roads is illuminating. Nothing can be said against the important Central railway line from Dar-es-Salaam on the coast to Kigoma on Lake Tanganyika, 780 miles long, as it is obviously the main artery through the centre of the country, and follows the previously established trade route into the interior. But it is interesting to know that it was pressed on to completion, and only reached its destination a few months before the war broke out, and almost the first "Merchandise" brought up from the coast, was a consignment of odd-looking loads, which were nothing more or less than a large armed steamer in sections for use on Lake Tanganyika. This vessel was put together at Kigoma where a naval dockyard had been prepared and fortified. The fact that the Germans considered it necessary to erect and arm fortifications on the margin of a peaceful African Lake is indicative of the point of view of all their actions in this part of the world.

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The railway from Tanga to Moshi, a military post under the shadow of the great Kilimanjaro mountain, about 220 miles long, bears however a distinctly menacing aspect, especially as it was intended to prolong it straight on to the Victoria Nyanza. Most fortunately for us this extension was not completed in time. When it is realised that Moshi was the principal point of concentration of the German forces in East Africa with the object of securing the roads on both sides of Kilimanjaro and from whence to carry out raids on the Uganda railway, to which it runs nearly parallel and only about a hundred miles distant, it cannot be considered a friendly railway.

The general trend of the roads is S.W., and they are curiously parallel, about 100 miles apart. But the most unfriendly road is that between Lakes Tanganyika and Nyasa which was made long after the British "Stevenson Road" from Karonga via Abercorn to Kituta, and runs parallel to it; in one place not more than a few hundred yards away. There are still greater menaces to peace with neighbouring territories in the form of strongly fortified and armed posts at strategic points such as Bismarckburg, Kigoma, Kissenje, Bukoba and others. Owing to these carefully thought out and very practical preparations, the situation in East Africa at the outbreak of war was decidedly in favour of the Germans, and the British, Belgians and Portuguese were caught almost entirely unprepared.

Officially, the Germans had an establishment of some 250 armed Europeans and 2,500 trained native "Askaris" called Police, but it is stated that these numbers were exceeded. By calling up every German settler, and the crews of the merchant ships, all of whom had been trained either in the regular army or navy in Germany, it is stated that a force of over 4,000 trained whites, and some 30,000 natives were available by October 1914, together with over 60 field guns and 100 machine guns. These troops were organized into companies, each 150 to 200 strong. Those companies composed of natives were stiffened by 10% whites, and each company usually had two machine guns. To these must be added the ten 4·1″ guns from the *Konigsberg* after she had been forced to seek refuge up the Rufigi River in September 1914, and field mountings for these guns appear to have been ready in a remarkably short time. The quantity of ammunition stored in the country must have been very considerable as the Germans have been able to continue the fighting right up to the present time, although a strict blockade of the coast has been in force since February 1915, and considerable quantities have been captured from time to time.

On the part of the neighbouring British and allied territories, the news of the declaration of war caught them all equally unprepared. In British East Africa the only trained troops were the King's African Rifles, natives with British officers, some 1200 all told. The greater portion of these were a great distance away to the North in Jubaland on the Somali border, the remainder were split up in microscopic detachments, acting as police, scattered far and wide over a great expanse of territory. There were also some native police equally widely scattered in British East Africa and Uganda. To the South,

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there were no troops at all in Northern Rhodesia, the majority of Rhodesian Police being employed much further South. In Nyasaland a few King's African Rifles acted as police.

Within a fortnight of the outbreak of war all the available white settlers in the British territories adjacent to German East Africa had joined up as volunteers including one Boer Unit and an Arab Company, but the utmost that could be done was only a small fraction of the numbers that the Germans could place in the field. The reason is not far to seek. The united areas of the British territories are together many times the size of the British Isles, but the total white population, including women and children, was under 7,000. Nyasaland, over five times the size of Wales, had only about 900 whites all told. The difficulties of arming, equipping and training even the small number available, at so great a distance from any arsenal or depôts, can well be appreciated.

The first reinforcement to arrive at Mombasa was the 29th Punjabis from India in September 1914, but the first troops to come to the aid of the British in Nyasaland were the South African Imperial Service Contingent, about 1000 strong, who arrived in September, 1915, or thirteen months after war broke out.

To give some idea of the intentions and preparation for war on the side of the British, it is interesting to note the number of steamers on the chain of frontier Lakes, remembering that everything depended on seizing the command of the lakes at the earliest opportunity. On Victoria Nyanza it is stated that there were three small steamers unarmed and with native crews untrained to use of arms, whilst the Germans had a fairly large steamer carrying a 27 pdr. gun as its principal weapon besides machine guns, and had a trained crew. Later on, in March 1915, after the arrival of certain naval ratings from the coast, lent by the Royal Navy, it became possible to meet and eventually drive the German vessel ashore. On Lake Tanganyika, there was one small Belgian steamer, no British boats, two armed German steamers, and a fairly large one, the *Götzen*, being put together at Kigoma dockyard. The Belgian was soon put out of action, but later, at the end of 1915, the tables were turned by the arrival of a naval detachment at the Southern end of the Lake.

On Lake Nyasa, very fortunately, the British possessed an armed steamer very similar in size and armament to the one which the Germans had previously launched on that lake. Without it the arrival of reinforcements at Karonga would have been most seriously delayed.

At the outbreak of war therefore the situation on the Lakes can only be described as very considerably in favour of the Germans, and with their superiority of force they at once established the command of the Victoria Nyanza and Lake Tanganyika.

The comparatively compact shape of their country with its prearranged lines of communications gave them the great advantage of superior mobility on interior lines.

The initial operations were not very complicated, the main object of the British on the North being to defend the Uganda Railway

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from the raids organised by the Germans and to check the advance of small enemy columns.

A more definite and immediately important objective was to cut the wireless communications of the German possessions with each other and with Germany. The first to be destroyed was that at Dar-es-Salaam on August 8th, when the British cruisers *Astrea* and *Pegasus* bombarded the place and landed a party for the purpose. Incidentally it may be interesting to note here that the powerful wireless station, only just completed before the war broke out, at Kamina in Togoland, which connected direct with Nauen near Berlin, was blown up by the Germans themselves to save capture by Colonel Bryant's column on 25th August, 1914. Duala Station in Cameroon fell to General Dobell on 26th September, and Windhoek Station was surrendered, uninjured, to General Botha in May, 1915.

Another interesting naval operation occurred on Lake Nyasa, where, on the 8th August, 1914, the British armed steamer *Gwendolen* set out to seek and destroy her opposite number, the German *Herman-von-Wissmann*, which was successfully accomplished by the 13th. But on Lake Tanganyika the Germans made a mistake—they disabled the Belgian steamer and, on 22nd August, the day before the battle of Mons, bombarded Lukuga, thus wantonly infringing the neutrality of the Belgian Congo. This decided the Congo authorities to assist the French against Cameroon and the British in East Africa. Later, when Germany saw that the loss of her African colonies was inevitable, she actually attempted to invoke a clause in the Berlin Agreement by which the neutrality of most of central Africa could be proclaimed.

The Germans lost no time in taking the offensive. A column from Moshi seized Taveta on 15th August, and simultaneously a strong military post was established at Longido, thus closing both avenues of approach round Kilimanjaro. Detachments were then pushed towards Voi and other points on the Uganda Railway, and continuous efforts were made to cut this important line of communication.

Another German column from the frontier post at Kissenje, north of Lake Kivu, surprised and captured the Belgian post at Ngoma. Only two miles separated these frontier posts on the important road which connects Belgian Congo and German E.A. and is here practically a defile between the lake and the mountains to the North.

In September, the enemy made an advance up the coast-road from Jassin, across the frontier via Vanga towards Mombasa. The garrison of Vanga retired "in face of superior numbers." It is illustrative of the paucity of the means at the disposal of General Stewart, who commanded in British East Africa at this time, to know that this garrison of a frontier town on a main avenue of approach consisted exactly of one officer and seven native troops. The German advance was however checked at Gazi after a sharp action on Sept. 23rd. Reinforcements having arrived at Mombasa the detachments guarding the Uganda Railway were strengthened, while the white volunteers were being trained and organized into two bodies, the East African Mounted Rifles and the East African Rifles,

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and every effort made to collect troops and material near Magadi on the branch line North of Kilimanjaro district, and at Voi.

On 12th September a somewhat serious raiding force of Germans advancing Northwards on Eastern margin of Victoria Nyanza, was checked after a severe fight at Kisii.

About the middle of October it was decided to attempt an advance round both flanks of Kilimanjaro with the columns such as they were, and to capture Tanga with the Brigade expected from India. This force, called the Tanga Frontier Force, comprising a British Battalion, Indian and Imperial Service Troops, about 6000 in all, left Bombay in the latter part of October. The transports arrived off Tanga on 2nd November, when a period of grace is said to have been magnanimously given to the German authorities so as to get their women and children out of the place. If this be true it cost us very dearly, as the Germans employed the time in hurrying up a considerable force of Europeans with field guns and many machine guns from Moshi, and in preparing for a stubborn defence with every kind of device to check the impending attack of which they had been so fully warned.

Two attacks were made; the first, with only a small force, totally inadequate for the purpose, can only be looked upon as a reconnaissance in force. On the 4th November, the main attack was delivered, through dense forest, and advanced to within 800 yards of the enemy's position when it came under very heavy fire. On the left flank, nearest the sea, the 101st Grenadiers with great gallantry fought their way into the town and crossed bayonets with the enemy. On the right the 2nd Battalion Loyal North Lancashires and the Kashmir Rifles reached the outskirts of the town, but were compelled to fall back to 500 yards range. In view of the heavy casualties, (795, including 141 British Officers and men) and the wholly unexpected strength of the place, the attack was now abandoned, and the troops re-embarked for Mombasa where they became part of the forces for the defence of British East Africa.

Simultaneously General Stewart had set out from the neighbourhood of Magadi with a composite column about 1500 strong, to seize the Longido position. A night march of about 15 miles was followed by an attack at dawn which met with a very stubborn resistance. The fighting lasted all through the day until between 7 and 8 p.m. when for want of water, the Germans holding the only water supply in the neighbourhood, the troops had to be withdrawn and marched back some 15 miles. But the Germans had lost heavily and had been so well shaken that they evacuated their position.

An effort was also made about the same time to recapture Taveta by a column advancing from Voi up the Asavo River, but meeting with considerably superior strength and stubborn resistance, this had also to be abandoned.

It was thus patent that the British forces at this period were not yet of sufficient strength to attempt any considerable offensive movement, though, in December, a column advanced Southwards from the neighbourhood of Gazi, drove the German patrols and advanced posts

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on the Coast road across their frontier and, with the help of the Royal Navy, occupied the line of the Umba and Jassin River. The Germans however were soon re-inforced and re-occupied Vanga on 12th January, 1915.

It is interesting to note that in the defence of Jassin by a small British garrison, it is stated that three German machine guns were smashed up by direct hits from a mountain gun at a range of only 300 yards.

Meanwhile, at sea, in September, the cruiser *Pegasus* was surprised in Zanzibar harbour while overhauling her machinery and was sunk by the longer ranging guns of the *Königsberg*. But this was the latter ship's last effort as she was soon afterwards chased and forced to hide herself up the Rufiji River where she was subsequently destroyed.

In January 1915, the island of Mafia was occupied by a combined naval and military force with only slight loss, and during this and the next month, Dar-es-Salaam and other ports were bombarded; at end of February a blockade of the whole coast was declared.

Some naval ratings and guns were now sent to Victoria Nyanza, and during March, after a little touching up by expert hands, the three small British steamers on the lake sallied forth, found the German steamer *Mwanza* with her 27 pounder, drove her ashore, and thus secured the command of the lake.

Repeated raids were made by parties of Germans against the Uganda Railway, principally from Taveta. Only on three occasions did they reach the line and cause slight damage; at one point several Germans were found blown to pieces by their own explosive-hoist with their own petard.

On 29th April 1915, Major General Tighe took over the command of the British Forces in East Africa, and directed his whole efforts to preparing for the offensive into German territory. Much had to be done. A railway was commenced from Voi on the Uganda Railway towards Taveta across the waterless plains. The Engineers carried a pipe line from the Bourra Hills, N.W. of Voi, to railhead, but the size of pipe available could only supply about half the quantity eventually required. General Tighe's plan was to concentrate gradually all troops that could be spared from guarding the Uganda rail into two divisions which could eventually advance on both flanks of Kilimanjaro, with Kahe as the objective. These preparations continued ceaselessly all through the year 1915, and it was not until January 1916, that he was in any condition to commence his operations. Meanwhile the important gateway into German East Africa from the Congo, Kissenje, had been captured and re-captured, but in May 1915, it finally came into Belgian possession, and they gallantly held it, keeping the door open, as it were, for the eventual advance. This entailed a continuous series of raids against the German forces which were collecting from time to time for its recapture.

Another German military centre was at Bukoba, near the Western shore of Victoria Nyanza, where they had a wireless station, and whence raids were made into the Buganda country. It was decided to capture the place by combined land and lake operations under

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General Stewart. The main column was brought all the way from Nairobi by rail to Fort Florence thence by steamers, a total distance of about 480 miles. The combination proved successful, completely surprising the Germans on the 22nd June. Though the enemy put up a stout fight, they were eventually thoroughly defeated, and the fort with its wireless station was destroyed.

About this time some fighting occurred on the frontier line between Northern Rhodesia and German East Africa. Some Belgian troops had arrived to assist in the defence of Kituta, and some Rhodesian Police had reached Abercorn and Fort Saisi. One of the features of this area is the tall elephant grass, standing anything up to 12 or even 15 feet high. It afforded considerable cover and concealment for an attacking force and it was therefore a difficult factor in planning any defence. In September, 1915, the South African Imperial Service Contingent, about 1000 strong, arrived in Nyasaland, and General Northey took over the command of the troops in this sector.

Meanwhile the Germans had held command of Lake Tanganyika from August 1914, but somewhere at the end of 1915, a naval detachment reached the Southern shore of the lake with two motor boats in sections, of no great size but designed to carry guns. It is perhaps difficult to appreciate the immense labour and persistence required to bring such loads for so great a distance across such country. In the last week of 1915, the boats were launched and set out to find their prey. It was not long before the *Kingani* was captured, and although it took some time to find the *Hedvig von Wissman*, it only took a few minutes to sink her. The third enemy, the *Götzen*, sought safety behind the guns of Kigoma until the place was captured by the Belgians in July, 1916.

To the North of Tanganyika the Germans had made continuous efforts to drive the Belgians away from the Rusizi River, and the fighting had been very sharp. The principal action took place at Luvungi on 29th September, 1915, when the Germans advanced to the attack with field and machine guns. After a stubborn fight lasting over fourteen hours, the action appeared indecisive, but, as on several other occasions, the Germans retreated during the night leaving numerous dead on the field and abandoning much ammunition and military stores.

Towards the end of 1915 the situation began to improve. General Botha had brought his campaign in S.W. Africa to a successful termination, thus freeing a considerable number of troops. In November the Union Government undertook to send a limited number to East Africa, but so many volunteers came forward that no less than a brigade of South African Mounted Rifles and three of S.A. Infantry had disembarked at Mombasa by March 1916. A second mounted brigade reached Mombasa in the May following.

Meanwhile General Tighe's preparations had been going on ceaselessly. The railhead was now West of Maktau, but the weak point of the situation was still the necessity of guarding the 600 mile length of rail, resulting in great dispersion of force, and at many points along this great length of line the Germans and British were in touch.

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There was as yet not sufficient force concentrated to assume the offensive, but gradually, as troops could be spared, they were organised into two brigades; the 1st E.A. Brigade on the branch line about Magadi; the 2nd E.A. Brigade about Maktau, and these were gradually developed into two 'divisions' as the South African troops arrived.

By 15th January, 1916, General Stewart with 1st Division moved to Langido and General Malleson moved his division (2nd) to Mbuyuni on the 22nd, turning out a German outpost.

It was known that the enemy had created a strong advanced position at Salaita covering Taveta. The rail and pipe line were pushed on to within a few miles of this position, and on 12th Feb., on the very day that General Smuts sailed from South Africa to take up the command of the Forces in East Africa, General Malleson carried out a reconnaissance in force of the Salaita position, thereby obtaining valuable information.

General Smuts arrived in the Northern theatre on February 19th and decided to adhere to General Tighe's plan of pushing in two columns from Longido and Mbuyuni converging on Kahe near the Ruwa River. But in view of the strength of the Salaita position, and others which the enemy might take up in dense bush behind Taveta, Van der Venter's 1st South African Mounted Brigade was now transferred from Longido to Mbuyuni with the object of carrying out turning movements, and thus possibly obviate the necessity of costly frontal attacks.

By the 4th March, all was ready for the advance, and on the following day General Stewart's column moved from Longido striking S.W. between Kilimanjaro and Mount Meru. Having further to travel, this column was given two days start. Van der Venter started on the evening of 7th March, with his 1st S.A. Mounted Brigade and the 3rd S.A. Infantry Brigade, making a night march so as to seize the high ground near Lake Chala and develop a turning movement round to the N.W. of Taveta. Next morning the 2nd Division moved against the Salaita position, entrenched, and prepared to attack supported by the Corps Artillery. All went well. The Germans were completely non-plussed to find Van der Venter's mounted men astride the road to Moshi behind them. This, together with the bombardment of their position, caused the Germans to evacuate not only Salaita but Taveta also.

On this day (9th March 1916) Portugal joined in with the Allies by declaring war on Germany, and prepared to move columns northwards across the Rovuma River from Mozambique.

Early on the 10th, the 2nd Division advanced to Taveta, but a delay was necessitated for the improvement of the crossing of the Rumi River so as to take heavy motor lorries. The enemy had now taken up a position with a strong rear guard on the Latema-Kitovo Hills, in dense bush, from which it was necessary to dislodge them before any further advance could be made. The great difficulties of the attack in thick forest was here illustrated, the principal difficulty being the separation of the attackers. The second attempt, at night with the bayonet, also failed through the same cause, but small parties

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led by officers secured footholds on the ridge and held on. Next morning it was found that the enemy had retired, but pursuit was practically impossible through the tropical forest which extends from Kitovo Hills to Kahe.

Meanwhile, Van der Venter was moving West towards Moshi meeting with only slight opposition from the enemy, but with great difficulties from the natural obstructions of the country, as the bridges were all destroyed by the Germans in their retreat. It is to be noted that all the rain-bearing winds in this region blow off the Indian Ocean from the S.E. and, striking the great mass of Kilimanjaro on that side, the rain falls and flows back to the Ocean whence it came in innumerable streams from the mountain sides towards the S.E., S., and S.W. Many of these streams are perpetual owing to the great snowcap and immense glaciers which cover the great mountain which is over 20,000′ high. Between the Latema-Kitovo Hills and Moshi the road crosses no less than eight considerable rivers and many minor streams. Further West towards Arusha the mountain torrents descending from Mount Meru are even more numerous.

On 13th March, Moshi was occupied unopposed by Van der Venter's Mounted Brigade, the enemy having withdrawn southwards towards Kahe to concentrate with the forces retiring from Taveta. The 2nd Division was now concentrated at Himo River crossing and at Taveta, with detachments in touch with the enemy to the South. On the following day, 14th, Stewart with the 1st Division got into touch with Van der Venter at New Moshi after overcoming various difficulties along the road from Longido, the enemy having broken the bridges.

No further advance was possible until 18th, the infantry being employed in the strenuous labour of improving roads, while supplies had to be brought up, transport reorganised and reconnaissance made.

General Smuts now decided to drive the enemy south of the Ruwa River so that space could be obtained for rail extension and further advance, and, in view of the approach of the unhealthy rainy season in this region when the valley of the Ruwa would become fever striken, so that he could get the enemy behind an obstacle which could be watched by a minimum of troops while the remainder could be withdrawn up the slopes of the mountain into more healthy quarters.

On the 18th and 21st stiff fighting occurred in the dense tropical forest of the Ruwa Valley, the enemy occupying the south edge of a clearing invisible to artillery with flanks on two parallel rivers flowing into the Ruwa, and offering considerable difficulty to passage by troops. Frontal attacks were only possible, though gallant efforts were made to turn the flanks. But here again the value of a mobile mounted force was demonstrated. Van der Venter's mounted brigade from Moshi, after a night march, captured Kahe Hill, the key of the German position, on the morning of the 21st. The enemy had blown up the railway bridge across the Pangani and made a final desperate effort to regain Kahe Hill, but were repulsed. At dawn on 22nd patrols found that the whole German force had taken advantage of the cover of night to effect the passage of the Ruwa River and had

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withdrawn to a new position astride the road towards Tanga. One 4·1″ gun was found abandoned but destroyed, the other, mounted on an armoured train, got away. Meanwhile Arusha had been occupied by the Scouts of Van der Venter's Mounted Brigade who had driven off a German Company in a southerly direction, and thus the whole of the Kilimanjaro-Meru region, the best in all German East Africa, had been occupied and cleared of the enemy.

Hitherto General Smuts had continued and developed the plans of General Tighe which he found prepared and on the eve of being carried out when he arrived in the country. The short time available before the advent of the heavy rains expected at the end of March, and lasting until the middle of May, had not allowed of any great changes without postponing the advance until the latter date.

The first phase having been successfully accomplished, the General was in a position to review the situation and having decided on his plan of operation, determined on a reorganization of his forces into three divisions instead of two, and to collect East African and South African Units under their own officers. One division to include British, Indian and local units, the other two being composed entirely of South African Troops. The detail by Brigades may be of interest:

1st Division.

(Hoskins) including 1st E.A. Brigade (Sheppard) and 2nd E.A. Brigade (Hannyngton).

2nd Division.

(Van der Venter) included 1st S.A. Mounted Brigade (Manie Botha) and 3rd S.A. Infantry Brigade (Berrange).

3rd Division.

(Brits) included 2nd S.A. Mounted Brigade (Enslin) and 2nd S.A. Infantry Brigade (Beves).

The 2nd S.A. Mounted Brigade did not arrive at Mombasa until May, and took the Field in latter half of June.

There were four alternative lines of advance open to Gen. Smuts:

(i) From the coast working inland along the existing railways. (ii) On Tabora from the Victoria Nyanza region, (iii) S.E. from his present position along the Tanga Railway to strike at German main forces in the Pare and Usambara Mountains. (iv) Southwards from Arusha into the interior towards the Central Railway.

There was no clear or well-defined objective, no important centres, practically no roads, and the only economic feature worth considering was the central railway line. But there were two considerable factors, which determined the General's decision—climatic conditions, and the enemy's dispositions. In the Kilimanjaro-Tanga district heavy rains with fever in the low lying parts would prevail for the next two months practically prohibiting continued operations by white troops, while westwards and in the interior, the rains would be later. Hence any immediate action considered necessary should if possible take place from Arusha, southwards. The enemy had evidently concentrated the bulk of his forces astride the rail and main road leading S.E. towards Tanga, even the six companies opposing Stewart's advance from Longido had retired via Kahe. The enemy

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possibly considered that along the Tanga rail lay the probable, if not the only, line of advance for the British.

General Smuts decided on a bold and, to the German Commander, a wholly unexpected plan of operations, thereby presenting an instructive example of the true value of the initiative. Instead of conforming to the enemy's plans he compelled success by forcing the enemy to conform to his. Van der Venter was to take advantage of the climatic conditions obtaining in the centre of German East Africa, and move at once from Arusha southwards to Kondoa Irangi. This would, it was anticipated, draw off considerable numbers from the German main body in front of General Smuts. By the time this was completed, the rains would probably have ceased in Kilimanjaro-Pare Mountain region, and Smuts with the main body would be able to move against a reduced number of the enemy, who were to be manœuvred rather than forced out of their successive positions along the railway by outflanking operations on both their flanks.

Van der Venter started on 3rd April on his 120 mile thrust across the great Masai Steppe. At daybreak on the 6th when, it is said, the horses had been without water for over 60 hours, the first watering place along this little known track had to be fought for, and by the 19th Kondoa Irangi was occupied. Hundreds of horses had unfortunately been lost en route from horse sickness, and those that survived, together with the men, were well nigh exhausted, but an excellent strategic position had been secured. The tropical rains in the Kilimanjaro district interfered considerably with the traffic of the supplies, and, practically isolated in the heart of German territory, the 2nd Division had to exist on local supplies. The effective force of this division was reduced by privation and sickness to a bare 3000 rifles, but it had achieved its object. It had attracted no less than 25 Companies or 4000 picked men, under the leadership of the German Commander-in-Chief in person, towards it. These delivered a determined attack on Van der Venter's attenuated force on the 9th May, during which four distinct assaults were made. The fighting was fierce and lasted 8 hours until 3 a.m. on morning of 10th, when the enemy withdrew beaten. An immediate offensive by Van der Venter would have had far reaching results but his force was in no condition to effect this.

Leaving Van der Venter securely settled at Kondoa Irangi on 10th May, and turning to General Smuts with the main body about Moshi, we find him preparing to advance as soon as the rain ceased. This happened about the middle of the month, and on 18th, the turning movements towards the S.E. commenced. The Pare and Usambara Hills run in parallel ridges and end somewhat abruptly along the Southern edge where the Tanga-Moshi Railway marks their limit. Between this rail and the Pangani River itself there is a great strip of dense tropical bush about 20 miles wide. Sending a column South-Eastwards along a track well to the N. of the railway, Smuts with the main body moved along the left bank of the Pangani, thus every prepared position of the enemy astride the rail was turned successively to their great chagrin.

By the 29th May it was ascertained that the enemy were evident-

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ly turning Southwards towards Handeni, whereupon Smuts decided to change direction likewise and crossed the Pangani, but sent on General Hannyngton's (2nd E.A.) Brigade to occupy Wilhelmstal and Korogwe then to turn S.W. to rejoin the main body. Handeni was occupied on 20th June by Sheppard's 1st E.A. Brigade and on the 24th the enemy were defeated in a stiff fight in that neighbourhood.

The main British force was now confronted by the Nguru Hills on which the enemy were well posted and entrenched. The men were exhausted by the arduous marching from 18th May to 24th June through 200 miles of very difficult and hilly country, while the line of communications still led back through Taveta and Voi to the sea base Mombasa, as Tanga was still in Germans hands. General Smuts now decided to halt and rest his troops pending the capture of Tanga and the opening up of a shorter line of communications.

(Compare Wellington's change of base from Lisbon to Santander, and Kuroki at Feng-huang-cheng, re-based on Antung).

On the very day that Smuts defeated the Germans near Handeni (24th June) and settled down to rest his troops, Van der Venter again moved forward, thus making the second series of reciprocal movements which proved so successful. The advance of the main body had drawn off a considerable number of the enemy confronting the detachment at Kondoa Irangi, and, being rested, Van der Venter commenced by driving off the Germans in front of him. Three columns were now pushed on towards the Central Railway; Kibombo, Dodoma, Kilimatendi, being the objectives; while a fourth column was pushed out 80 miles westwards to Singida where a detachment of Germans was established. The latter was forced to surrender after a stiff fight.

By the end of July over 60 miles of the important rail from Kilimatendi to Dodoma were occupied, and Van der Venter pushed S.E. towards Kilossa so as to be ready to co-operate with the advance of the main body Southwards round the Nguru Hills. Meanwhile Tanga had been captured on the 7th July by a combined attack from land and sea, and General Smuts was in a position to resume his advance. Again adopting wide turning movements so as to manœuvre the enemy out of his strong position rather than needlessly waste men in frontal attacks, the British main body moved round both sides of the Nguru Hills through very difficult country, which together with broken bridges, greatly hampered the progress of the supply and transport. The enemy evaded these movements by retreat and eventually concentrated on prepared positions about Dukawe on the Wami River. On 16th August, enveloping movements were again commenced for the capture of this position but the enemy retired on night of 17/18 August on Mrogoro.

Van der Venter was now approaching from the West. He had forced the road defile at Kidete and came into a stiff action with the enemy near Kilossa on 21st August. A mounted detachment was sent by General Smuts to the S.E. of that place during night of 21/22 August, to assist him, but by morning of 22nd Van der Venter

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was in possession of Kilossa and was pressing the enemy Southwards on Uleia, a point where roads branched off to Iringa and Mahenge.

This appears to have had considerable effect on the German main force at Mrogoro as they retired via Kitope and Matombo to the Uluguru Hills, and Mrogoro was occupied by Sheppard's and Beves' brigades on 26th August.

Sandani had been occupied by naval forces on 1st August, and Bagamoyo on the 15th, thus bringing potential bases ever closer up to the area of active operations. A land column was also moving Southwards parallel to the coast to clear the country and with the eventual object of capturing Dar-es-Salaam. But without waiting for this, General Smuts decided to push on without delay and give the retreating enemy no respite. On the 28th still another series of enveloping movements were commenced with the object of turning the enemy out of his positions in the Uluguru Hills. The main body passed round to the East via Matombe, another column moved round the West via Kitobe, small columns pushed through the hills, while a mounted force swept up the country still further West and co-operated with Van der Venter's force which had reached Kikume, 42 miles S. of Kilossa. The combined mounted forces then pushed on to seize the passages on the Great Ruaha River.

After the most arduous marching through difficult country, during which much of the wheeled transport had to be abandoned, a junction of the columns was effected on September 15th at Kissaku on the Mgeta River, the fragments that remained of the enemy retiring in S.E. direction towards the Rifiji River and towards Mahenge. Meanwhile Dar-es-Salaam, with its large civilian population was captured by combined operations of the coastal column and the Royal Navy, thus opening a new base with its important railway connection to the interior.

It is now time to turn to the operations of the several other columns—British, Belgian and Portuguese, which had been moving into the great area of what was German East Africa from various points. These can only be dealt with very briefly in the time allowed. In the N.W. the Belgians had captured the German Frontier Post at Kissenje and established an open door for subsequent advance. As their line of communication back into the Congo was of great length and difficulty, it was arranged that General Smuts should be responsible for their supply and transport from a base on the West shore of Victoria Nyanza. In April Colonel Molitor was able to advance and reached Kigali on 6th May. To assist this advance and to co-operate eventually in the capture of Tabora, a British column moved southwards across Victoria Nyanza, captured Ukerewe Island on the 9th June and forced the Germans to evacuate Mwanza on the south bank on 14th. This place now became the base for the further Anglo-Belgian operations against Tabora, to which two good roads led.

Another Belgian column had collected at their railhead at Lukuga on the West Bank of the Tanganyika, and, assisted by other troops advancing from Usambura at the N. end of the lake, and from Kirando 100 miles from S. end of lake, captured Ujiji with its dock-

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yard at Kigoma during July. The German forces under General Wahle retired slowly towards Tabora. The Rhodesians, Nyasaland contingent and the South Africans, now under General Northey, operated in several columns. One of them captured Bismarckburg and others were set in motion towards Iringa. After a stiff fight on 24th July Malangali was occupied, the object being to join up eventually with Van der Venter and thus draw a net across the country separating Wahle's force from Lettow Vorbeck's main body so as to be better able to deal with them in detail. The point of convergence of the advancing Anglo-Belgian columns being on Tabora and to East of it, Wahle was forced to retire Eastwards. Several stubborn engagements were fought West and North of Tabora, but the British column from Mwanza moving on a point further East compelled the Germans to retire still further along the railway, then, to avoid the advanced troops of Van der Venter from Kilimatinde, Wahle had to turn South-East. Tabora was occupied on 11th September and the allied columns immediately followed up in pursuit of the Germans.

Meanwhile General Northey had reached Iringa on 29th August and was establishing a chain of fortified posts to guard his communications back to Rhodesia and Nyasaland and to prevent if possible the junction of the two German forces. General Van der Venter was also pushing southwards from the railway to join up with General Northey.

The whole line to be held was of considerable length, about 250 miles—roughly from London to Holyhead, Birmingham representing Iringa—and the country is hilly and mostly covered with dense bush. The difficulties of holding this line were considerably increased by the question of supplies which became very serious.

From 22nd October to end of November General Wahle attacked several of these posts only to meet, in most cases, with severe repulse, and a German column moving westwards from Mahenge to assist Wahle was intercepted by General Northey and severely defeated. Heavy rains now set in bringing operations almost to a standstill, but under cover of this paralysing weather Wahle managed to escape towards Mahenge with the small remnants of his force, leaving all his guns behind. The advance of the main body under General Smuts had also come to a stop owing to sickness amongst the troops and transport troubles due to climatic and abnormal 'natural' causes. The tse-tse fly had caused very heavy losses amongst the horses during the approach to the Great Rusha and Rufiji valleys, and a considerable portion of the white troops were striken with fever and dysentery. The mechanical transport had also reached the limit of its endurance through want of opportunity to effect repairs and through sickness amongst its personnel, while transport animals of every kind had perished by thousands.

During November-December of 1916 it was decided to disband the 3rd Division, and nearly 12,000 white troops were sent out of the theatre of operations. These were replaced by extra battalions of the King's African Rifles, the Gold Coast Regiment and a brigade of Nigerian troops, the latter arrived at Dar-es-Salaam about Christmas Day.

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SKETCH MAP
strating the Operations in East Africa

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A brigade was now sent by sea to Kilwa whence it moved north-westwards towards the rear of the remnant of the main German force which had by now been driven into the Rufiji valley.

On 1st January, 1917, the general advance was resumed and a passage over the Rufiji was secured, the enemy retreating in detachments eastwards towards Utete. Other enemy forces about Mahenge also retreating southwards under pressure from Generals Van der Venter and Northey.

These operations are now under the direction of General Hoskins who took over the command on 20th January on the departure of General Smuts to attend the meetings of the War Cabinet in London.

The complete success of the converging movements has not yet been attained. The difficulties under which the operations are being carried out are immense. It is however a hopeless struggle for the enemy and can only end in one way.

GENERAL CLEEVE: Ladies and gentlemen, I think that the next duty that falls to me is to ask that we should offer a very hearty vote of thanks to the lecturer for his very lucid and well-constructed lecture. It is a lecture that will be extremely instructive to anybody and very much more so to people who have not had any opportunity of making a special study of the subject. Of course, we all hope that the war will come to an end before very long and that the German representatives who are still holding out there will be captured. The lecturer has told us a great deal about the war and I think it has been very instructive. The plans and maps give a very good idea, but when they are supplemented by photographs they give colour to the lecture. I will ask you, please, to join me in a hearty vote of thanks to Major Phillips for his very instructive lecture.

MAJOR PHILLIPS: General Cleeve, ladies and gentlemen, I am exceedingly grateful for the kind way in which you have listened to me and still more for your kind commendation.

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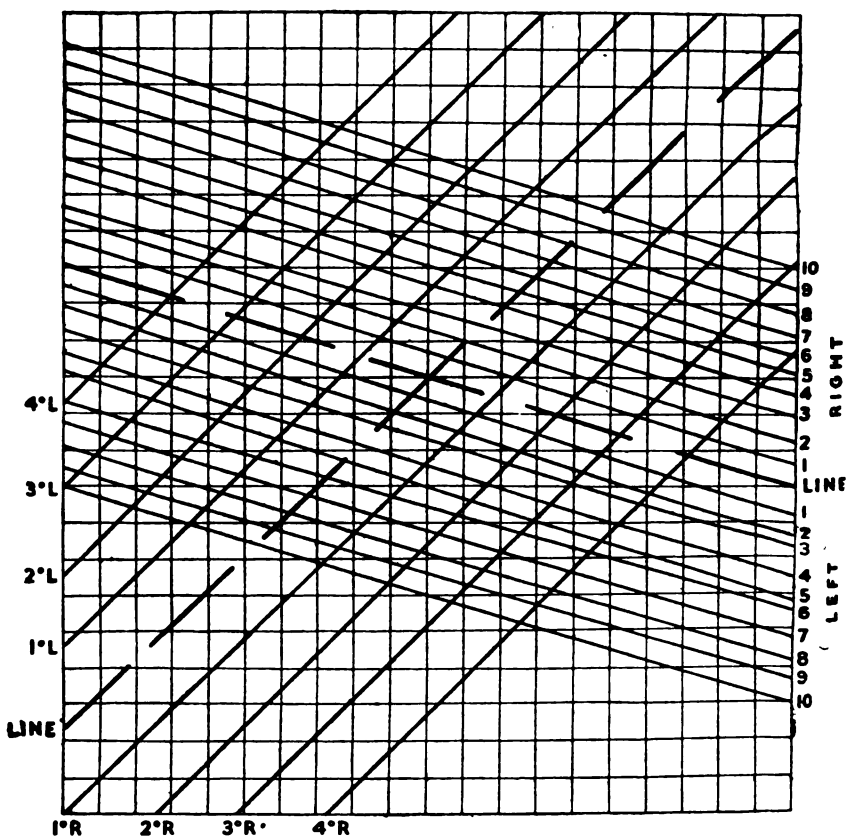
THE SIMPLEST GRID.

By Major J. Grose, R.G.A.

THE Grid described in the March Journal has a competitor for the title of "Simplest" whose claim rests not upon Simplicity in construction—in this there is little to choose between the two—but in simplicity in plotting the results.



To construct the Grid:—

Take a page of A.B. 152 and mark your "target" in the middle where two blue lines cross. The space between the horizontal lines represents 10 mins. elevation: the space between the vertical lines represents 10 mins. of deflection.

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First work out factors $\frac{E}{O}$ and $\frac{D}{O}$ for each observer. Put them in the form $\frac{?}{60}$.

Then mark off spaces on the vertical line through "target" each equal to the numerator of the factor $\frac{E}{O}$ for the right observer. And mark off spaces on the horizontal line through "Target" each equal to the numerator of the factor $\frac{D}{O}$ for right observer.

Join up the corresponding marks (using parallel rulers if available) produce the lines so drawn to near the edge of the page. Mark the lines in degrees R and L for right observer. Draw a line parallel to the others through the target to represent line observations.

Do the same for the Left Observer.

Plot a round by using these pencil lines and the blue lines on the paper will give the results in minutes of elevation and minutes of deflection.

EXAMPLE.

Factors. (See "Table of Angles").

6″ B.L. How. 26 cwt. Charge 3lb. 8¼ oz. Cordite. Range 4000.

E = 23

Left Observer.	Right Observer.
Apex 15° Range 3000 ⅄	Apex 45° Range 1000 ⅄
$\frac{E}{O}=\frac{23}{59}=\frac{23}{60}$	$\frac{E}{O}=\frac{23}{243}=\frac{6}{60}$
$\frac{D}{O}=\frac{23}{59}=\frac{23}{60}$	$\frac{D}{O}=\frac{85}{243}=\frac{20}{60}$

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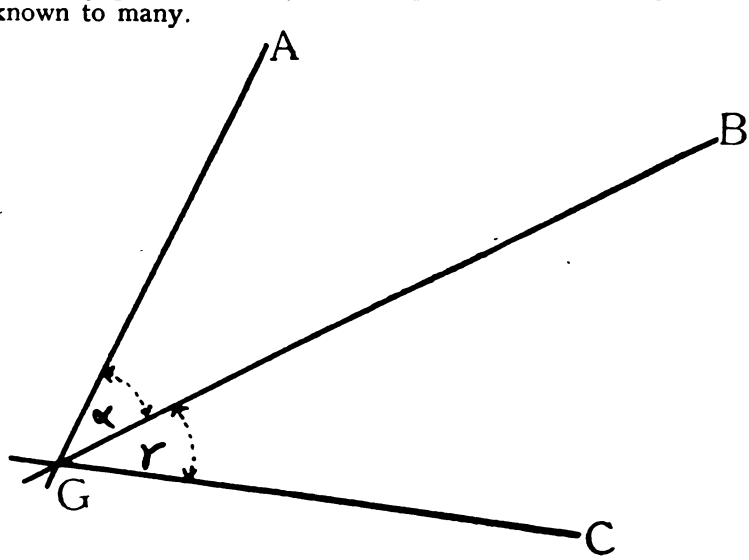
LOCATING POSITIONS ON MAPS.

By Captain J. Powrie, H.A.C.

WITH reference to the article by Lieut. H. S. Rowell, R.A. "On locating positions on maps" p. 384 of R.A. Journal for January 1917, I would point out that the second method is not new, but is very well known in Navigation, more especially in marine surveying. The station pointer, described in most works on this subject, utilizes this principle. The following is a very simple way of applying this principle:—Construct the angles AGB and BGC on tracing paper, as shown in the diagram below. Place the paper on the map and adjust so that the place A on the map is on the straight line AG and the points B and C on BG and CG respectively. The point G will then be on the required position. The angles AGB and BGC are, of course, measured by director, sextant &c. in the first instance. This method is quick, does not spoil the map with a lot of construction lines and compass holes and gives wonderfully good results with a little practice. A few pieces of tracing paper are easily carried in the map case. No drawing compass is needed. The use of tracing paper in this way as a simple form of station pointer is well known to many.



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As regards the use of the rising or setting sun, mentioned near the close of the above article, I would point out that there would probably be an error unless the sun rose or set over a sea horizon. On the dates mentioned, the azimuth correction would be simple, viz. (Angle of sight to crest over sun set) ÷ (tangent of 90 degs. — latitude of place), approximately.

The polar distance of Polaris should be multiplied by secant latitude to find its azimuth at any place. For instance in the North of France the azimuth would be as much as 1 degree 40 minutes instead of 1 degree 8 minutes 35 seconds given at the foot of p. 386. The abridged Nautical Almanac gives on p. 162 a table for finding the azimuth of Polaris.

Some directors will not elevate enough to get on to the Pole Star except in low latitudes.

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THE KILLING POWER OF PROJECTILES.

Translated from the Revue Militaire Suisse—January, 1917.
By Captain G. de L. Landon, M.C., R.F.A.

FOREWORD.

It would be idle, before the end of the present war, to pronounce a definite judgment on the effects either on personnel or material of modern projectiles. We must wait until the military experts have drawn from the lessons of practice the principles which will assure to the defence adequate protection against the weapons of the attack. Two famous sieges, those of Port Arthur and Adrianople had recently provided opportunities for appreciating to a certain extent the effects of fire on defences and defenders. It will be agreed that the tests were not conclusive. To-day, to employ the words of General Lewal "the belligerents have industrialized war"; they have turned to their service all the progress realised in armament, electrical communication, mechanical transport, and aviation. Nowadays mechanical transport assures the employment and ammunition supply of the heaviest artillery, which formerly was limited in its action to the neighbourhood of railways. The accuracy and rapidity of fire of field batteries, the intensity attainable by rifle fire and the more general use of machine guns, together seem to have had decisive influence on the stationary character of the operations. To forestall a success or to retain possession of conquered territory the opponents have not hesitated to entrench themselves along the whole battle front employing all the various resources of modern semi permanent fortification. For the out-and-out offensive, originally intended by the German General Staff and recognised dogmatically in the majority of Field Service Regulations, is substituted the offensive-defensive. The tactician must resign himself to the organization of a defensive position the immense extent of which should deny to the enemy every path of invasion or permit of the gradual recoil of his own battle front. He must be content with the fighting methods appropriate to sieges and the slow progress afforded by such operations as sapping and mining. The manœuvre battle has to-day but a passing character.

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The determining factor in this evolution of modern warfare is to be found in the improvements carried out in weapons and explosives. From them has resulted a notable increase in fire effect; thence the inportance of a careful determination of the effects of projectiles both on personnel and material. The former, the aim of which is to place living targets *hors de combat*, are obtained by rifle and shrapnel bullets and to a less extent by the explosive effects of shells of small calibre; the latter are the results of the explosion of shells of medium and large calibre, the aim of which is the destruction of shelters and obstacles, though their action affects at the same time both the garrison and the heavy defence of forts and redoubts.

The man-killing, or rather man-stopping, effects of projectiles as attained by the bullets and the breaking up of the shells alone form the subject of this study. Having recalled to mind some principles of exterior ballistics indispensable to the proper understanding of the subject, we will consider the projectiles first individually and then collectively; we shall then be in a position to formulate some conclusions as to the defensive siting of trenches and the protection of their defenders from shell and rifle fire.

EXTERIOR BALLISTICS.

To justify the importance of some knowledge of this subject I will cite the authority of Capt. Collon of the Belgian Artillery. In his "Traité pratique des tirs collectifs" this writer sums up in the following terms its influence on fortification: "The general theory of fire effect and a thorough knowledge of the properties of trajectories, considered either individually or collectively, constitute an indispensable factor in the choice of positions, both for defensive and offensive purposes." Colonels Piarron de Mondésir and Clergerie of the French engineers, express in somewhat different form an identical opinion contained in two very complete treatises relating to the connection between fortification, tactics, and armament. It would be superfluous to insist further on this point. The limited nature of this study will only permit us to recall some essential principles relative to the fundamental properties of trajectories and to the striking action of projectiles.

Gallileo, towards the end of the 16th century established the equation of the jet in its simplest form. He showed that an object, thrown freely into space, described a parabola on a vertical axis. The physical properties of gases being unknown at this period, he neglected the retarding action of the air. It is known that the parabolic trajectory is only attained in the hypothetical case of a vacuum; we must take into account besides the acceleration due to the weight, the resistance of the air, which according to Newton should be proportional to the sectional area of the projectile, the square of its velocity and the density of the atmosphere. This principle, admitted for a considerable time, gives sufficiently accurate results only when

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the initial velocity is less than 240 metres (790 ft.) per second or more than 420 metres (1390 ft.) per second. Our compatriots Euler and Jæn Bernonilli of Basle continuing the work of their predecessors, smoothed the way for the famous geometricians Borda, Gauss, Cauchy, and Piobert who laid the foundations of a new science following on that of dynamics. The development of rational mechanics allows us to establish with a slight approximation the equations of the trajectory in a vacuum and in the atmosphere.* The results of experience confirmed the speculative researches of the savants. For initial velocities not conforming to Newtons law, that is those of the majority of long range weapons, M. Siacci admits the cube proportion except between 282 metres (925 ft.) per sec. and 343 metres (1125 ft.), in which case the air resistance would increase in proportion to the sixth power of the tangential velocity. As can be understood, without resource to calculation, the atmospheric action has a perceptible effect on the movement of the projectile; it no longer describes a parabola, as in a vacuum, but an unsymmetrical curve of which the ascending branch has a greater amplitude than the descending branch. The principal results of this lack of symmetry are as follows:—

1. The angle of departure is always greater than the angle of descent ($\alpha < \phi$).

2. The tangential velocity and the radius of curvature for inclinations of the trajectory equal and opposite in sense, are greater in the ascending than in the descending branch.

3. The abscissa of the highest point of the curve is greater than half the range i.e. distance from origin to point of impact.

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* According to Morel these equations can be put in a relatively simple form which it is interesting to recall.

Trajectory in the vacuum: $y = x tg\alpha - \dfrac{gx^2}{2V_0^2\cos^2\alpha}$ (1)

Trajectory in the atmosphere: $y = x tg\alpha - \dfrac{gx^2}{2V_0^2\cos^2\alpha}(1+KV_0^2x)$ (2)

From equation (2) we deduce by the ordinary methods of the differential calculus that of the tangent to the curve at any given point and from thence at the point of impact making $x = R$ (the range). You get for the angle of decent ϕ.

$$tg\phi = tg\alpha\left(1 + \frac{KV_0^2R}{1+KV_0^2R}\right) = tg\alpha\left(1+\frac{S}{1+S}\right) \quad (3)$$

We have adopted the following signs: x, y the co-ordinates of the centre of gravity of the projectile; α angle of departure; $g=9.81$ metres per sec., the acceleration due to the force of gravity; V_0 initial velocity at the muzzle in metres per second; R the range.

$K = \dfrac{V_0^2\sin 2\alpha - gR}{gV_0^2R^2}$ ballistic parameter, function of the locality and the weapon.

$S = KV_0^2R$ auxiliary constant.

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The principles enunciated above give rise to several complementary remarks. We have ignored the angle of jump r, practically negligible and varying with the extent of the recoil, vibration and heating of the weapon. Actually it is added algebraically to α so that you have $r \pm \alpha = \pm i$ where i = the angle of projection. Again the trajectory is generally regarded as a plane curve by reason of its small point of departure; this hypothesis is only correct for the material point compelled to remain during its course in the same vertical plane as the line of projection, not for the projectile considered which is a revolving body, cylindrical or truncated in form, the axis of which is animated with a conical movement known as precession, and an oscillatory movement at smaller periods known as nutation. This somewhat complex movement is favourable to penetration and diminishes the loss of kinetic energy. Nevertheless the rifle bullet, on account of its relatively small weight, has a tendency to see-saw about its centre of gravity. An attempt has been made to minimise this tendency by the substitution of the bi-ogival shape for the cylindro-ogival. As to the shrapnel bullet; it has a maximum effective flight of little more than 150 metres and starts from the bursting point of the shell so that its velocity is combined with that of the shell. Thus it is partially freed from the influence of the rifling of the gun and of the resistance of the air. It has therefore been possible to retain for the shrapnel bullet the spherical form originally common to all projectiles until the appearance of the Dreyse needle gun (1841) and of the rifled cannon (1859). To appreciate the dynamical action of the bullets and splinters, the penetration of which depends upon the range and the material of the target, we must evidently refer to the equation of kinetic energy—K.E. = $\frac{1}{2} m v^2$ where m = the mass of the projectile, i.e. the proportion between its weight and the acceleration due to gravity, v its velocity at the point of impact.

The man-killing power of projectiles depends then upon the initial velocity, the weight, and the shape of the bullets or splinters. Certain numerical data relative to these elements are evidently indispensable for a reasonable estimate of the "striking" effects of which we will make a brief study.

THE "STOPPING" POWER OF BULLETS AND SHELL SPLINTERS.

The irregular manner in which the body of a shell breaks up makes difficult the calculation of the remaining striking force or kinetic energy of its splinters. We will therefore consider more particularly the action of shrapnel and rifle bullets. The kinetic energy equation shows that for a given increase of velocity, which is the preponderating influence, you may have a considerable decrease of weight without loss of energy, and with the gain that, at long ranges, the projectile is less exposed to air resistance. This double improvement, that is, the increase of initial velocity and decrease of calibre has been realised by the replacement of mechanical ex-

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plosives by chemical ones. In fact the invention of colloidal powders, with a base of pure nitrocellulose or the latter mixed with nitro-glycerine, due to the French engineer Vieille, has allowed of obtaining initial velocities such that the effective fire distances have been nearly doubled (800—1000 m. for infantry, and from 4 to 5 kilometres for field artillery). There resulted a change of armament which took place between 1886 and 1892 in the case of the small-arms, while for economical and manufacturing reasons the creation of a new artillery material was deferred till about 1897.

To Vieille belongs the honour of being the first to discover a really stable ballistic explosive, produced by the gelatinisation of gun cotton discovered in 1846 by the Basle chemist Schoenbein dissolving cotton cellulose in sulphuric and nitric acids. When mixed with nitro-glycerine this powerful ballistic is sometimes used for filling shells; for rifle cartridges it is generally used in its pure state but with an increased degree of nitrification. It is powerful enough to impart to the rifle bullet an initial velocity of from 600—650 metres per sec. which, owing to recent improvements, has even increased to over 850 m. per sec. The power of this explosive naturally brought about a reduction of calibre (6.5 to 8 mm.) and thus a decrease of weight in the projectile, at first to 14 or 15 grammes and later to 10 or 12 grammes when the cylindro-ogival shape was replaced by the bi-ogival in 1898. The fore-part of the bullet became very tapering—almost pointed—while the hind part adopted a slightly conical form. To lessen the deformation due to the heat produced on striking, the hardened lead containing from 2 to 10% of antimony employed for a long time in the manufacture of the bullet, was wrapped in an envelope of some hard metal, copper, nickel-steel or German silver (alloy of 50% copper, 25% nickel, and 25% zinc). This hard casing increases its penetration in solid material but diminishes the spreading effect of the projectile, that is, its surface of attack. With the bi-ogival shape the striking force at the muzzle was increased from 300 kgm. to 350 kgm. At the usual fighting distances, the remaining striking force is still sufficient to inflict grave hurt, e.g. at a range of 800 metres it is between 65 and 70 kgm. (430—465 ft. lbs.) and at 2000 metres it is not less than 20 kgm. (133 ft. lbs.), the remaining velocity being 250 m. per sec.

Some concrete examples will better serve to illustrate the progress realised in the infantry arm since the adoption of the colloidal powder. In Table I are collected the chief ballistic data relating to our former cartridge and those of two foreign armies. They are interesting for reference as showing the pronounced difference in the trajectories at the two ranges selected.

The comparison of the man-stopping effect of the shrapnel bullet and the rifle bullet is generally unfavourable to the former; but before formulating conclusions it is expedient to recall the elements which go to influence its striking action. As we know, it consists of a small sphere of hardened lead of weight varying from 9 to 13 grammes, and diameter from 11.77 mm. to 13.2 mm., the corresponding cross sections being then from 1.075 sq. cm. to 1.368 sq. cm. Thanks to

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the use of nitro-cellulose, preferable as a ballistic to nitro-glycerine on account of its greater stability and feebler erosive action, modern shrapnel has an initial velocity of 500—580 metres per sec. and has at the bursting point E a remaining velocity V_1 which decreases from 420 m. per sec. to 250 m. per sec. as the range increases from 1 kilomètre to 4 kilomètres. Taking into account V_1 and the velocity imparted by the explosion of the charge within the shell we get a resultant velocity V_2 for determining the striking force at the point of impact; V^2 may be taken as from 350—520 metres per sec. for average ranges of field artillery. The bullets at the farthest limit of the cone of dispersion have still a velocity 180 metres per sec. corresponding to a distance from the bursting point of 150—200 metres and a striking force of 15 kgm. per sq. cm., sufficient to place a man *hors de combat* (for a horse 30 kgm. per sq. cm.). Note that the spherical form of the bullet is justified not only by economic reasons but also by the uncertainty of the direction it will take at the bursting point and the short distance it travels.

All the pieces of medium calibre, siege guns such as the 155 (long), the majority of light howitzers such as the 155 (short) and 120 (short) fire shrapnel shells much more powerful than those of the field guns, and containing 250—500 bullets weighing 20—65 grammes in place of 300 bullets of 9—13 grammes.

In Table II are given the principal ballistic data of three modern types of shrapnel shell, also the steepest inclination of the cone of dispersion at 4000 metres. The maximum angle of descent of the artillery projectile serves us as a basis for our study of the defensive measure to be taken.

We have up to the present only considered the mortal effects of bullets without taking into account the question of wounds more or less grave. It is obvious that the gravity of the wounds is also an element in the effect on personnel, which does not depend altogether on the striking force. According to Colonel Bircher the human body has three vulnerable zones subject to mortal, severe, and slight wounds respectively; the areas of these zones are in the proportions of 25, 15, and 60 for rifle bullets and 30, 25, and 45 for shrapnel (25 gr.). It would appear that these results must be modified to the detriment of the gun and to the advantage of the rifle since the adoption for the latter of a bullet with hard metallic envelope and a flatter trajectory. From both the tactical and ballistic point of view, it is sufficient to determine the minimum remaining striking force necessary to place living targets, men or horses, *hors de combat*. Captain Campana of the French artillery deduces from the experiments of General Journée a general classification of the wounds produced by the shrapnel bullet; the chief points are reproduced in Table III.

We now have the elements necessary for a comparison of the effects of rifle and shrapnel bullets. The pointed shape and hard envelope of the former facilitate their penetration in hard matter such as bone, the parapets of trenches, gun shields and snipers shields; the latter produce more serious wounds on account of their larger striking surface and the spreading out of the lead ball in mushroom

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shape, but they have the disadvantage of striking the target with much feebler force.

The explosions of high explosive shells occasion wounds, if not more grave, at any rate more painful than the two projectiles already studied. The H.E. shells of small calibre belong to two distinct types; the first, having a thin casing and a heavy charge (825 gr. of mélinite), produces a very dense fragmentation consisting of about 2000 small splinters with an initial velocity of 1200 metres per sec. (3937 f.p.s.) (the French 75); the second (the German 77), with a thick casing and small charge (135 gr. picric acid), breaks up into about 500 fragments of varying weights (10—200 gr.) with a relatively small initial velocity (300—400 metres per sec.). To sum up we may say that shell splinters are capable of producing very serious lacerated wounds on account of their irregularity in shape, their large surface of attack, or of the kinetic energy developed from the explosion of disruptive explosives such as mélinite, lyddite, émmensite, écrasite, and chimose. These different varieties of explosive are all derived from picric acid [C_{12} H_3 (AzO_4) $_3O_2$], produced by the nitrification of phenol, which with the addition of di-nitro-cellulose dissolved in a mixture of ether and alcohol, was employed by the French chemist Turpin as early as 1885 for the charging of torpedoes. To-day trotyl, peroxide of nitrogen, is sometimes substituted for the derivatives of phenol. The French "75" shell has not only striking but also considerable shock effect, or violent expansion of the gases given off by the combustion of the powder when the explosion occurs in a confined space; it is therefore capable of demolishing a house or shelter, and producing in a man within four metres of the explosion internal hemorrhages which are always fatal.

Besides the two characteristic types of shell, the fragmentation of which we have shortly described, field artillery employ others whose action is similar. For example the German H.E. shrapnel (285 bullets, 100 splinters of 5 grammes, and 140 gr. of explosive) is very efficacious against shielded guns; the French Robin shell, a species of shrapnel with a heavy mixed charge and 300 bullets, has great incendiary properties and is superior to all similar projectiles in use before the war from the point of view of results obtained and ballistic coefficients.

Although the destruction of the enemy is generally attained by rifle fire, time shrapnel, and small H.E. shells we should not pass over in silence the sometimes considerable effects on personnel of shells of medium calibre. Their employment, formerly limited to breaching and demolishing fire, has become generalised since the war of position has assumed an extent hitherto unknown. Again, special circumstances have led to the intervention of heavy pieces in the artillery struggle in open fighting; thus the Germans realizing the inadequacy of their 77 material, have given their counter-batteries the excellent 105 howitzer. The pieces of medium calibre (90—155 m.m.) fire shells weighing from 12 to 43 kg., charged with explosive weighing in some cases over 10 kg. In Table IV are given some

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data relative to the total weight and weight of the charge of some medium calibre shells actually in use on the Western Front.

This short study of the striking effects of bullets and splinters will allow us better to appreciate the results to be expected on personnel from shells burst in air and rifle fire; they have had a decisive influence on the present methods of fighting and on the defensive organization of the battlefield according to the modern conception of war. Having considered the individual projectile, we will study the various groupings of weapons which go to make up the whole; its efficacity is subject to the distribution of the arm, the control of fire, and the slope of the ground.

Table I.

Ballistic Data (rifle)	SWITZERLAND mod. 89/96 Schmidt-Rubin cal. 7.5 m.m.	FRANCE mod.86/93 Lebel cal. 8·0 m.m.	GERMANY mod. 88 Mauser cal. 8·0 mm	FRANCE balle M 98 D. Lebel cal. 8.0 m.m.	GERMANY balle S. 1903 Mauser cal. 7·9 m.m.
Initial velocity at the muzzle, metres per sec.	600	632	645	726	875
Weight of bullet in grammes.	13·8	15	14·7	12·8	10·0
Charge in grammes.	1·9	2·75	2·75	3·0	3·2
Angle of descent ϕ in degrees — 800 m	2° 05′ 04″	1° 51′ 06″	1° 47′ 03″	1° 00′ 50″	1° 05′ 00″
Angle of descent ϕ in degrees — 2000 m	14° 42′ 10″	13° 48′ 32″	12° 51′ 45″	——	——

N.B.—The maximum range of the new Swiss rifle is between 3400 and 4000 m. for the bi-ogival bullet which has an angle of descent of about 20° with negligible remaining K.E. The ballistic data of the armoured Swiss bullet of 1911 which we have not considered it advisable to reproduce permit us to expect from our rifle (mod. 96/11) results equal or superior to those of the best modern weapons.

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Table II.

Ballistic Data (field gun)	German 77mm. mod. 96n, A Krupp	Swiss 75 mm. 1905 Krupp	French 75 mm. 1887, Deport Ste-Claire-Deville
Initial velocity at 25 m. from the muzzle in metres per sec.	465	485	529
Shrapnel: Total weight	6·850 kg.	6·350	7.240 kg.
Shrapnel: Weight of charge (internal)	·570 kg.	——	·700 kg.
Shrapnel: Spherical Bullets: number	300	210	298
Shrapnel: Spherical Bullets: weight	10 gr.	12·5 gr.	12 gr.
Shrapnel: Spherical Bullets: diameter	12·2 mm.	13·1 mm.	12·9 mm.
Angle of descent, ϕ, at 4000 m.	13° 31′	13° 10′	11° 39′
Average opening of cone of dispersion K at 4000 m.	9° 30′ (approx.)	8° 22′	8° 37′
Steepest inclination of cone at 4000 m. ($W = \phi + K$).	23° 01′	21° 32′	20° 16′

N.B.—The maximum range of modern field artillery is between 5500 m. and 6500 m.; however the progress realised since the war started has allowed of exceeding the limit indicated.

Table III.

Striking force in kilogrammètres per sq. c/m or foot lbs per sq. in.	WOUNDS.	
	MAN.	Horse.
Below 2 kgm or 10·8 ft. lbs.	Contusions.	———
2 – 4 kgm. or 10·8 – 21·6 ft lbs.	Wounds more or less deep in soft parts.	Contusions.
4 – 8 kgm. or 21·6 – 43·2 ft lbs.	Bones bruised.	Wounds more or less deep in soft parts.
15 kgm. or 81·2 ft. lbs.	Bones broken & pierced	Bones cracked.
30 kgm. or 162 ft. lbs.	———	Bones broken & pierced

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Table IV.

Weights and charges of the principal shells of medium (heavy artillery) on the Western Front.

Species and calibre of Piece.	FRENCH.					GERMAN.			BRITISH
	Canon long 155 T.R.	Canon Court 155.	Canon Court 120.	Canon Long 105 T.R.	Canon long 9° Bange.	Heavy Howr. 150 Krupp.	Canon T.R. 180 Krupp.	Light Howr. 105 Krupp.	4·5 Howr.
Total weight of Shell (kg.)	43	43	20·3	16·5	12	39	14	14	17·5
Weight of Charge (kg.)	12	12	6	—	2·1	7·3	1·6	1·6	2·7

(To be continued).

R. De Diegbach,

Captainè du Génie.

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PRÉCIS OF REVUE MILITAIRE SUISSE.

(February and March, 1917.)

By Captain G. de L. Landon, M.C., R.A.

February, 1917.

Cavalry Study.

A study of the action of the cavalry of the 1st and 2nd German Armies from the 4th Aug. to the 4th Sept., 1914. The conclusions drawn are favourable to the German cavalry and interesting light is shed upon some of the actions during the Retreat, particularly that at Nery on the outskirts of the Forest of Compiègne, where British troops captured a number of German guns.

Tsing-Tao.

A short account of the siege of Tsing-Tao (Aug.—Nov. 1914) by the Japanese assisted by two battalions of British troops.

Impressions from the Austro-Hungarian front.

An account of the fourth battle of the Isonzo 12th Nov.—5th Dec., 1915, by a Swiss officer attached to the Austrian Army.

March, 1917.

Cavalry Study.

Continuation of article appearing in February number. A study of the action of the German Cavalry during the battle of the Marne (4th-10th Sept., 1914). The account of the battle itself should interest officers of all arms.

The training of infantry for battle.

A summary of the lessons to be drawn from the present war.

Chronique Belge.

Some interesting remarks on the re-organization of the Belgian Army after the retreat from Antwerp.

Chronique Portugaise.

Contains a brief résumé of the Portuguese official memoir relating to the military co-operation of Portugal on the Western Front.

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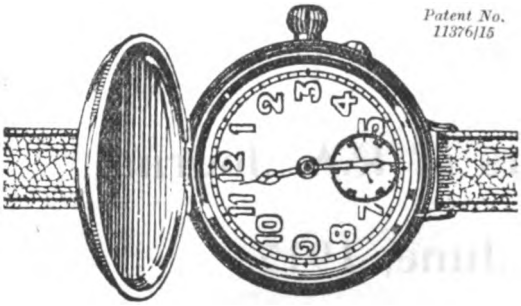

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FRIEDLAND, 1807.

By Major A. F. Becke, late R.F.A.

(Continued from page 44).

PART III.

THE BATTLE OF FRIEDLAND, SUNDAY 14 JUNE, 1807.

(Vide Map 3).

The Dawn of Modern Field Artillery Tactics.

Dédié à la mémoire de M. le général de division Alexandre-Antoine de Senarmont, un grand artilleur du Premier Empire.

"Les grandes batailles se gagnent avec de l'artillerie".

Napoléon—(Corr. 20,929).

"That side will obtain an unconditional tactical preponderance which best knows how to make use of its artillery."

May ("A Tactical Retrospect").

"J'ai ordonné des batailles qui ont décidé du sort des empires; l'ordre n'en partait jamais que de ma volonté réfléchie et arrêtée."

Napoléon.

Opposing Forces.

(a) French.

The total strength of the Grand Army engaged in the battle was about 95 Infantry Battalions and 146 Cavalry Squadrons, or 80,000 men, and 200 guns;* the following corps taking part in it in the order named:—

Lannes' Corps, Grouchy's Cavalry, Nansouty's Cavalry;
Mortier's Corps, Latour Maubourg's and La Houssaye's Cavalry;
Ney's Corps;
Victor's Corps;
And the Imperial Guard.

The actual strength during the Battle increasing as stated:—

At 3 a.m., Lannes and about 10,000;
At 8 a.m., Lannes and about 25,000;
At noon, Napoleon arrived and assumed the chief command;
At 5 p.m., Napoleon and about 80,000 men.

(b) Russians.

Engaged on the Russian side there appear to have been about 160 Infantry Battalions, with 180 Squadrons of Cavalry and 19 Regiments of Cossacks, making altogether about 7 Divisions of a total

* Vide Appendix A for a detailed Order of Battle of the troops engaged at Friedland.

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strength of 60,000 with about 300 guns. The artillery was both numerous and of a powerful description.*

The force when finally deployed was arranged as follows:—

Right Wing—4 Divisions under Prince Gortschakov;
Left Wing—2 Divisions under Prince Bagration;
Cavalry Right Wing—General Uvarov and Prince Galitzin;
Cavalry Left Wing—General Kollowgribov.

Reserve { To cover the Bridges, 12 Battalions with some squadrons and some batteries were left on the Right Bank of the Alle.

The Battlefield.

The small town of Friedland is on the left bank of the Alle, placed in an elbow of the river which flows between very steep banks in the vicinity of the place, the right bank commanding the other and being the more precipitous. The town was joined to the right bank by a long wooden bridge. Generally speaking the river was unfordable in the neighbourhood and the fords that were subsequently discovered were apparently unknown when the battle opened, and even then they were so deep that they were only practicable with great difficulty.

To the West of the Town lies the ground on which the battle was fought, and it is cut into two parts by the deep and narrow ravine in which flows the scarcely fordable Mill Stream. At first this stream running northward through Posthenen flows almost parallel to the Alle; then, when about 600 yards north of the village, it turns sharply right handed and running east and west across the battlefield it enters the Alle immediately below Friedland thus restricting still further the area available for the place in the elbow formed by the river; also immediately to the West of the town the place is further cramped by a large pond, or lake, through which the stream flows.

To the northward of the Mill Stream lies an extensive and open plateau across which runs the Könisgberg road, the plateau being bounded on the west by the Heinrichsdorf stream. To the South of the Mill stream and East of Posthenen the country is of a different type, being undulating and well wooded; and across it, through Posthenen, runs the main road to Georgenau and Eylau. This road keeps to the higher ground above the Mill Stream until it reaches Friedland.

At the time of the Battle the whole area was covered with crops.

Russian Positions and Plans.

(a) Positions.

On June 13 General Galitzin with 20 Squadrons and 20 guns had driven out the 9th Hussars from Friedland and pushing them back towards Georgenau, a Russian outpost line was taken up on the front Heinrichsdorf—Posthenen—Sortlack, thus securing Friedland with its bridge and covering the bridgehead.

* Wilson states (p. 23), "When the Russian Army was in Poland above 500 cannon moved with it generally, and were actually in the Battle of Eylau."

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It was at about 11 p.m .on the night of 13/14 June that the Russian Army reached Friedland and as, during Midsummer in these high latitudes, there is hardly any night, 2 Divisions proceeded at once to cross the Alle covered by the original outpost line; and gradually almost the whole army followed and deployed along the line shown in Map 3; having 4 Divisions to the N. and 2 Divisions to the S. of the Mill Stream which flowed perpendicularly through the front of their main position. A reserve of 12 Battalions and a few Squadrons at first remained on the right bank, whilst several batteries were posted on the same bank covering the permanent as well as the temporary bridges—an ominous precaution.[1]

(b) Bennigsen's Plan.

From prisoners taken by his cavalry Bennigsen learned that in front of Friedland there was only Oudinot's division and some cavalry.[2] His first idea had been that he would give his army a day's rest at Friedland, and to safeguard it he reinforced his advanced cavalry with 2 Divisions. Later he heard that the French had been reinforced, whereupon he gradually sent across the river nearly the whole of his army, leaving on the right bank only about 10,000 out of 60,000 as a small reserve. Further he dispatched detachments to secure the bridges lower down the Alle in order to cover his march on the morrow. Having failed to march together he was now going to make as conspicuous a failure of striking together. There is no doubt that the Russian General allowed himself to be drawn piecemeal to the left bank and then he allowed the fight to develop into a general action when the Grand Army was massed on the field—a battle that he could have no desire to deliver. He must have realised the proximity of the Emperor and the Grand Army; and if he meant to fight Lannes' Corps then he should have deployed his whole strength as rapidly as possible and annihilated it by 10 a.m., withdrawing immediately across the river and hastening northwards; or if he intended to risk remaining in front of Friedland then he should have secured Heinrichsdorf and arranged to hold it at any cost; then, when he desired to do so, he could have opened his retirement on Allenburg without being driven into the Alle.

Further when he decided to strike on the left bank he should have done something more to secure his force from disaster than merely leaving a small body of all arms on the right bank. Common prudence suggested that some rough earthworks should have been thrown up covering the entrances to Friedland and a special garrison told off to hold them at any cost, in order to protect the retreat of his army if it was forced to recross the Alle during daylight. No foresight was used, everything being left to chance; consequently if the Russian Army was beaten in front of Friedland it was more likely to meet with an appalling catastrophe than a mere defeat.

But there can be no doubt that the soundest course was not to risk a fight at all and not to rest until the army was beyond the Niemen.

[1] By 9 a.m. the whole of the Russian Army (except the Reserve) was across the Alle. (Wilson, p. 155).

[2] On the French side there were about 3,000 cavalry and 7,000 infantry only on the ground at 3 a.m. on 14 June.

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The Russian General had no real plan; his feeble grasp of the situation and his infirmity of purpose made him the slave of every wind that blew; as a result he was first dominated by Lannes then he was mastered and his army destroyed by Napoleon.

Napoleon's Plan.

This was as simple as possible; Napoleon meant to make an early opportunity for delivering a pitched battle and then once and for all to finish the Russian Army. To this simple plan he adhered rigidly all through the brief campaign, and the Battle of Friedland was the direct result. In the battle itself there was only one general idea, although there were two distinct phases—one preparatory and the other decisive.

At the commencement Marshal Lannes' Corps acted as General Advanced Guard to the Grand Army, and on June 14 its duty was clear, it had to hold Bennigsen and the Russian Army in play on the left bank of the Alle during the advance of the Grand Army and its deployment for action.

On the arrival and deployment of the *Masse de Manœuvre*, towards 4 p.m., the final stage was reached, the Emperor had assumed the chief command, and then his one idea was to deal the Russian Army such a staggering blow that it would be hopeless for the Czar to consider any continuance of the campaign and he would hasten to make terms with the victor.

Preparatory Moves. The Advanced Guard Action.

About 1 a.m. on June 14, Lannes himself arrived at Posthenen, having received orders from the Emperor to take Friedland.[1] Despite the crushing superiority at Bennigsen's disposal Lannes never hesitated; he considered that he must deny to Bennigsen any opportunity to advance along the Königsberg road, he must hold him in play until the Emperor and the Grand Army came up and therefore he must cover the Eylau road and remain master of Posthenen, to facilitate its eventual deployment.

At the moment when the Marshal had received his orders to recapture Friedland, Oudinot's Grenadiers were his only available troops. The Marshal promptly ordered Oudinot to advance and seize the place; but on arrival at Posthenen the French found heavy masses on the left bank and Oudinot deployed his division as follows:—

The Right (2 Battalions) in Sortlack Wood, centre to the E. of Posthenen, with a battery of guns in action behind the village, and his left near Heinrichsdorf. To hold this extended front there were available only 9 Battalions and 18 guns. Had Bennigsen had a suspicion of the true state of affairs[2] and attacked Lannes' screen promptly then the French must have crumpled up when opposed by twice or thrice their own weight of numbers, that is if the Marshal had held to his original plan of attempting to hold the Russian Army in front of Friedland. But far from acting in this way Bennigsen

[1] Corr. 12751, written from Eylau at 3 p.m. on June 13.
[2] The fact that French Infantry had arrived in front of Friedland should have given the Russian Commander-in-Chief cause for serious anxiety.

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allowed the action to open with a great skirmishing fight.

A line of skirmishers was deployed all along the front and immediately opened the action; whilst Lannes, to carry out his allotted task, took full advantage both of the ground and of the height of the crops (with which the whole battlefield was covered) to hide not the strength but the weakness of the force with which he was attempting to keep Bennigsen in play until the Grand Army could be massed to complete the destruction of the Russian Army.

Bennigsen was deceived by Lannes' boldness and he considered that he was confronted by a considerable force, consequently he wasted valuable hours in a methodical deployment of his army and also in a long and useless cannonade.

Masking Posthenen the Russians advanced on Heinrichsdorf. On this flank the Cossacks were in force and they covered with a cloud the advance of their infantry. Lannes behaved in a somewhat similar way, behind a screen of skirmishers occasionally he threw in a whole battalion to drive back the Russian skirmishers. Also as more troops reached the field the Marshal formed two columns, each of a Brigade, engaging them alterately on the right and on the left, but always concealing their advance with such skill that he was successful on several occasions at different points.

Bennigsen attempted several attacks against both wings of the French Advanced Guard, but each time he was unsuccessful and Lannes managed to maintain his grip on the essential points of the battlefield.

The action had not opened long when at 3 a.m. General Grouchy rode up with his Division of Dragoons[1] and moved promptly to Heinrichsdorf to cover the French left and control the Königsberg road. Lannes now disposed of about 10,000 men. A considerable time before this Lannes had received the Emperor's letter,[2] written from Eylau at 9 p.m. on the 13th, telling him that Grouchy was coming to his assistance and to command his cavalry, and that Mortier's Corps was also starting for Friedland; that, if necessary, Marshal Ney's Corps would also march at 1 a.m., and Victor would be at Domnau by 10 a.m.

Lannes handled the slender force magnificently, made a fine use of the ground and helped by the successive reinforcements that reached the front, as the morning wore on, he managed to keep Bennigsen in play and caused him to believe that he was in touch with very superior numbers. On the French side it was a masterly display of correct Advanced Guard Tactics. Lannes was as skilful as he had been at Saalfeld (10 Oct. 1806) but far more audacious.

Between 6 and 7 a.m. Nansouty and his Cuirassier Division reached the field and he was closely followed by the leading division (Dupas', 6,000 strong) of Mortier's Corps; these troops proceeded to deploy on the French left to the north of Posthenen, allowing Lannes to mass Oudinot's grenadiers in front of the village. There is no doubt that this reinforcement was a most welcome one, for by now

[1] Apparently Grouchy was marching most of the night. He passed through Domnau about midnight.

[2] Corr. 12753.

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Oudinot's division, though still full of fight, did require considerable help if Lannes was to fulfil his real task of neutralising the Russian army.

Nansouty, on first arriving, formed his division to cover the French centre which was almost denuded of troops; in front of a heavy Russian attack, made to smash the French left and cut Lannes from the Eylau road, Nansouty, not knowing what was happening on either flank, withdrew his division at a trot; but Marshal Lannes sent to Grouchy a request that the cavalry should be sacrificed to arrest this turning movement. Grouchy galloped up, stopped Nansouty's retirement, gave him a formal order to re-occupy the line he had evacuated and then with his own Dragoons galloped off and wrested Heinrichsdorf from the Russians. The Russian Cavalry arriving, to turn the tables on Grouchy were routed by a magnificent charge delivered by Nansouty's Cuirassiers and Carabiniers, and the Russians retired into Friedland in extreme disorder. If Nansouty's original withdrawal was unwise and unnecessary it is certain that, directly the task he had to perform was made clear to him, he repaired the error promptly and in the most telling way. From this time onwards he handled his Division with skill and audacity, delivering several brilliant charges that contributed largely to the ultimate success that was achieved. Then towards 8 a.m. Marshal Lannes' remaining division (Verdier) arrived, and was used partly to support Oudinot and partly to drive Bagration's light troops from Sortlack wood. Verdier's arrival brought the total up to about 25,000 men, and with this force the Marshal had to engage the Russian Army during the rest of the preparatory phase of the Battle;[1] and by 9 a.m. Bennigsen's Army (at least 50,000 strong) having crossed to the left bank Lannes' task called for all his skill and determination. To the eyes of Lannes' outnumbered battalions the ever-growing Russian Masses must have loomed like a dark forest on the horizon.

The French reinforcements were noticed by Bennigsen, but that leisurely man was by no means perturbed and he decided to defend his position until nightfall—a course of action that could gain him no single advantage.

At first there was some sharp fighting near Heinrichsdorf and for a time the action swayed to and fro on this section of the field, so essential for the Russians to possess if they were to evade eventual disaster, but after some close fighting between Dupas and Grouchy and the Russian right the column that finally advanced along the Königsberg road was attacked by French horse and forced back. Then towards noon the action gradually died down and degenerated into a mere desultory cannonade along the front, both commanders, for widely different reasons, being only too anxious to prolong this non-committal phase of the action.

Arrival of the Emperor and the Grand Army.

It was noon before Lannes' responsibility ended; and then Napoleon reached the battlefield.

[1] For the front occupied by Lannes after Verdier's arrival see Inset A in Map 3. In this preliminary, or preparatory, action Sortlack Wood appears to have changed hands no less than four times.

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As the Emperor reached Posthenen, and was recognised, Oudinot's grenadiers acclaimed him with volleys of cheering, at last they realised that their endeavours were to be crowned with a great result.

Napoleon proceeded to carry out his first rapid reconnaissance, to convince himself that Bennigsen's main army was on the Alle's left bank, and then he wrote the letter to Murat already quoted.[1]

After Marshal Lannes had reported to the Emperor came the turn of General Oudinot. As he arrived the Emperor said to him, "I bring you the Army, it is following on my heels. If the enemy only remains a few hours longer in his present position, then he is lost." Oudinot had received his reward, the end he had striven for so gallantly was in sight.

The Emperor, as he had said, was followed closely by the Grand Army itself. First came the cavalry divisions of Latour Maubourg and La Houssaye, and they were followed by the Cavalry of the Guard. Then came Mortier's remaining division (Dombrowski), then Ney and the VI Corps followed by Victor and the I Corps. Then about 4 p.m. the Guard itself reached Posthenen, and Napoleon had concentrated about 80,000 men for the decisive battle. The Advanced Guard action was over and the battle was about to take a dramatic turn.

For 9 long hours Lannes had imposed on Bennigsen by his activity and daring. It was a remarkable feat. The opportunity had arrived to reap the fruits obtained by Marshal Lannes' tactical skill, Napoleon was quick to seize the chance.

Observers in the belfry at Friedland warned Bennigsen of the steady arrival of large masses of hostile troops and he must have recognised that he was confronted by the Emperor and the Grand Army. His previous passivity was largely responsible for the fact that he now stood as helpless as an ox in front of his butcher.

The Grand Army on arrival proceeded to form up as follows:[2]

Marshal Ney between Posthenen and Sortlack.

Marshal Lannes, as the opportunity offered, gradually drew in to his left and formed his Corps to the N. of Posthenen.

Marshal Mortier carried on the left of the line from the N. of the Mill Stream to Heinrichsdorf.

On the extreme left were Grouchy's Cavalry Division, as well as the Light Cavalry Brigades of Victor's, Ney's and Mortier's Corps. Latour Maubourg's Cavalry was put under Marshal Ney's orders to support the right wing, whilst Nansouty's Cuirassier Division joined Marshal Lannes.

TheReserve consisted of Victor's Corps, La Houssaye's Cavalry and the Imperial Guard,[3] which formed up astride the Eylau road behind Posthenen.

---

[1] Vide page 40. (Part I). "Before Friedland, 3 p.m., June 14."
[2] Vide Map 3.
[3] I have shown them formed up in rather different positions to the ones usually given on the maps. It seems certain that Victor would naturally have gone to the S. of the Eylau road, the right of the line, whilst the Guard, the final reserve would be kept nearer the centre.

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By this time it was clear to Napoleon that the main effort was to be made against the Russian left therefore the Reserve (Victor and the Guard) was massed behind the French right and right centre, so as to be available to engage without delay at the crisis of the action and drive home the main blow with irresistible force.

General Victor, on reaching the battlefield, received an order from the Emperor to form up in a fold of the ground and act as a reserve. Each Division was formed by Brigades half being deployed and half held in column on the flanks. This arrangement at once appealed to the troops, possibly because it emanated from the Emperor, who arranged the first Brigade himself. This "mixed order" of Battle was always Napoleon's favourite and whenever he intervened personally he invariably employed it.[1]

Seen from the Russian position all along the far horizon there was a girdle of glittering steel—a most impressive sight.

Bennigsen at last appreciated the extreme danger in which his army stood and he issued orders for it to retire to the right bank, but very shortly afterwards he recognised the impossibility of the manœuvre and counter-ordered the retirement. The army was fully committed and must fight it out on the left bank until darkness fell.

At the first glance the Russian position appeared to have something to recommend it, for both the flanks rested on the Alle, therefore an outflanking attack could not be carried out. But the position in reality was a most uncomfortable and dangerous one. The Russian left centre was obviously the vital part, if that was driven in great results must follow.

Whilst the Grand Army had been forming up Napoleon had carried out his real reconnaissance of the Russian position. At once he realised that Bennigsen had offered him an opportunity, even though the battle could not become general until the late afternoon. Instead of standing on the high ground behind the Alle and making the most of the wet ditch of the river, the Russian Army had crossed over and fought with the Alle behind it, whilst practically their only line of retreat lay through the narrow streets of Friedland; also the Russian front was broken by the deep ravine that carried the Mill Stream and made lateral reinforcement difficult. Napoleon appreciated all these points, and also that the promontory on which Friedland was placed was much restricted by the Mill Stream which prevented any movement into the town on a broad front. He determined to crush the Russian left, seize and hold Friedland; then any retreat to the right bank becoming impossible, the Russian Army could be destroyed where it stood. The Russian right was to be neutralised and held to its ground by a frontal attack, and thus prevented from reinforcing the left at the critical moment.

[1] The "mixed order" recommended by Guibert, 25 years before, was first used in the field at the crossing of the Tagliamento in 1797, on General Buonaparte's own order. Realising the tactical innovation that he had made, for the first time he described to the Directors his tactical dispositions. (Corr. 1589). To make the "mixed order" clear a sketch is given (Inset B on Map 3) showing the formation used at the Tagliamento. The "mixed order" combined all the advantages of a massed column as well as of a deployed line. It lasted as long as Napoleon himself.

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To put his plan into action Napoleon then wrote his famous attack orders[1] and issued them to the various commanders. To Ney, who was to deliver the vital thrust, he gave also some particular verbal instructions;[2] "Break into Friedland at any cost, take the bridges, and do not be uneasy at anything that happens on your right, on your left, or behind you. The Army and I will see to that." Orders well calculated to make Ney surpass himself and then his dauntless courage would command victory.

The Decisive Attack.

After the troops had rested for a short while, the Emperor at 5 p.m. gave the signal to Marshal Ney's Corps to attack, by opening fire from a battery of 20 guns in action near Posthenen. 3 Salvoes sent the echoes ringing and the decisive phase began. All along the French line of battle the guns opened a heavy fire to engage the attention of the Russians and co-operate with Marshal Ney's attack.

When Ney's Corps advanced the I Corps (under General Victor) moved forward and occupied the ground on which the VI Corps had formed up originally.[3] Dupont's Division in front formed in "the mixed order," and the other divisions, standing one behind the other, formed in a similar way. The day was drawing on and it was absolutely necessary that the Reserve should be ready and available directly the Battle was ripe for Napoleon to deliver his *coup de maître.* Ney's Corps (Marchand's and Bisson's Divisions) immediately advanced on Friedland; and as the ground hid the town itself Marchand took the belfry as a mark of direction to advance on.

In this first advance the Regiments of Marchand's Division formed only one column of double companies, apparently with the idea of passing through the edge of the wood and outflanking the Russians more readily. On their left Bisson's Division formed two Brigade columns in echelon.[4]

Before Ney's advance, Bagration drew back his troops on to the high ground to the South of the Mill Stream; as Marchand approached the Alle the frontal fire of Bagration's Artillery, in co-operation with a battery on the right bank and coupled with a prompt and resolute charge delivered by the Russian cavalry, drove Marchand back in disorder. Bisson warned by this deployed his Brigades. Marchand then rallied his division and once more regained the general alignment; but he deployed his battalions with the idea of developing a heavy fire and reducing the effect of the Russian fire; the long thin line of the 2 divisions extended for about 2000 ⅿ, its front being screened by a cloud of skirmishers who were engaged with the Russian light troops. It was a very still, hot afternoon and the smoke hung over the combatants enshrouding them in such thick, heavy clouds that it became almost impossible for the troops to see what they were firing at. After a sustained fire-fight this long line

[1] Vide Appendix B.
[2] Cust, ii, 42.
[3] This is an additional proof that Victor, on arrival, probably formed up on the right of the Guard and to the S. of the Eylau road.
[4] The approximate advance of these two divisions is shown in Map 3.

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was broken by a charge of the Russian Horse Guards and the whole Corps was routed.[1]

Now the Emperor intervened personally and he formed the reinforcing division from the I Corps (Dupont's) in the "mixed order", with one of the Brigades deployed in line and the 2nd Brigade of 6 Battalions in line of Masses. Three Regiments of Ney's Corps were not broken, and forming themselves into squares these living fortresses held out at the two extremities of the line.

On General Dupont advancing, his artillery (apparently 10 guns and under Captain Ricci) came into action as quietly as on the Parade ground and by its fire stopped the Russians who were pressing on after routing Ney's Corps; Latour Maubourg at once seized the opportunity to deliver a telling charge with his Dragoons.

General Senarmont (commanding Victor's artillery)[2] had accompanied Captain Ricci, however the General quickly realised that the unsupported battery was insufficient to control the superior Russian artillery and he rode back to get a reinforcement. Gaining General Victor's sanction, despite the protests of the Divisional Generals, he concentrated under his immediate command all the artillery with the I Corps; leaving 8 guns (4 12-Pdrs. 2 6-Pdrs. and 2 Howitzers) in reserve, to cover his flank in case of need or for use in any emergency. With the 30 guns thus obtained he formed 2 Batteries of 15 pieces each,[3] the right battery Colonel Forno,[4] the left under Major Raulot, and advancing with them brought them into action at

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[1] Although shallow formations were adopted to develop fire, yet it does appear to be a fair inference that heavy columns, like Marchand's, were used for manœuvring and under the eyes of the Emperor, and apparently elicited no condemnation; and this fact possibly conduced to these heavy formations being employed sometimes on very unsuitable occasions, and then with disastrous results, e.g. D'Erlon's Corps in its attack at Waterloo, 18 June 1815, to quote only one instance.

In Marchand's advance the Division, about 5,000 strong, had a frontage of only about 60 men.

[2] The following was the Artillery present with the I Corps:—

	12 Pdrs.	6 Pdrs.	4 Pdrs.	6″ Howitzers
Dupont's Division	2	8	—	2
Lapisse's Division	—	6	2	2
Villatte's Division	—	6	2	2
Reserve	2	2	—	2
	4	22	4	8

Total 38 pieces.

General Senarmont was appointed to command the Artillery of the I Corps in the place of General Faultrier, captured at Marienwerder. Previously General Senarmont had commanded the Artillery of the VII Corps (Auguereau) at the Battle of Eylau; and for his distinguished services in this great battle he had been made a Commandant of the Legion of Honour.

[3] Each battery consisted of:—

10	6 pdr. Field Guns.
2	4-pdr. Horse Artillery Guns.
3	6″ Horse Artillery Howitzers.
Total 15	

Senarmont's report to Victor, dated 15 June and written on the Battlefield of Friedland.

[4] This included Ricci's Field Battery.

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about 450 yards from the Russian line. As the enemy firmly stood his ground, after firing 5 or 6 salvoes Senarmont limbered up and advanced to within 250 yards of the Russians and then opened a heavy and continuous fire. The Russian Batteries on the right bank of the Alle were crushed in succession by a heavy converging fire from the 30 guns and then came the turn of the Russian infantry.[1]

Even the Emperor was astounded at Senarmont's audacity and he sent one of his General Aides de Camp, General Mouton,[2] to ascertain why the Artillery was being risked in such a close action. Senarmont answered, "Leave me to do it with my Gunners, I will reply to all." When General Mouton returned to report to the Emperor, Napoleon had already appreciated the full result to be gained by Senarmont's magnificent leadership and intrepidity and, laughing, he said, "These gunners are hotheads, let them be."

Senarmont's audacity was amply repaid by the success he gained. Seeing the terrible effect produced by the close, massed fire of his 30 guns and wishing to drive back the Russians, who fell in the ranks but refused to yield their ground, he gave the order to his two batteries (which by now had converged during their advance into a single unit) to limber up and he led them forward until they were within 150 yards of the Russians where they unlimbered again and opened fire. From now onwards the guns only fired case-shot[3] at the Russian Infantry which were crowded together on to a very restricted space, consequently they were speedily decimated by the case shot which ploughed long, red furrows through their deep masses. At this crisis the Russian artillery was rightly ignored and by Senarmont's orders his guns fired only at the Russian Infantry.

To relieve the tremendous strain thrown on their Infantry the Russian Cavalry advanced to charge the battery. Immediately Senarmont ordered the flank guns to change front half back and opening fire on the Cavalry as they closed the guns blew them away with 2 salvoes. In this final position the guns fired for about 25 minutes and the ground in front of them was littered with Russian dead.[4]

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[1] According to Clausewitz, "The fire of artillery produces greater effect than that of Infantry. A Battery of eight 6 pounders does not occupy a third of the front of a Battalion of Infantry, is worked by 1/8 of the number of men comprising a Battalion, and does certainly twice, if not three, times as much execution with its fire. . . . A great battery of 20 or 30 guns is in most cases decisive at the point where it is placed." "On War", (edition 1873), iii, 103-104.

As Clausewitz was occupied on his work between 1810 and 1830 his opinion is invaluable about the effect produced by artillery in the Napoleonic era. Senarmont's 30 guns were certainly decisive at Friedland.

[2] Afterwards (1809) Comte de Lobau; Commander of the VI Corps in the Waterloo Campaign; he became a Marshal in 1831.

[3] Effective range of case shot, about 400 yards; effective range of the smoothbore flint-lock musket of the period did not exceed 120 yards.

I have attempted to show on Map 3 the successive positions of Senarmont's guns.

[4] The total expenditure of gun ammunition by Senarmont's 30-gun Battery was 2516 rounds, of which 368 were case-shot. To-day a 6 gun Field Battery has expended more than twice the larger amount in 48 hours.

Senarmont's losses were 1 Officer (Colonel Forno) and 10 men killed, and 3 officers and 42 men wounded. The General had his horse (*un charmont cheval*) wounded under him, and he feared that it could not be saved.

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Dupont's Division now advanced supported by the fire of 5 guns, commanded by Colonel Forno (until the latter was struck by a bullet and killed).

The whole Russian left being routed began to fall back towards Friedland and very soon got crowded up in front of the town, between the lake and the Alle, the space became more and more restricted as greater numbers crowded back into it.

Bennigsen now attempted a counter-attack to save Friedland, and some of his Infantry and his Cavalry Reserve, crossing to the right bank of the Mill Stream, attacked the French left flank. For a moment things looked serious, but Dupont's Division checked the Russian Horse and drove it back in confusion among the Russian Infantry and the Russians were then driven back in disorder towards Friedland pursued by the victorious French.

The resistance of the Russian left wing was really broken. Dupont deployed into line as he closed with the Mill Stream and Ney once more advancing detached a whole battalion to act as skirmishers and clear the ravine. On approaching Friedland, and street fighting appearing inevitable, Dupont formed the 59th Regiment of the Line in close column and threw it into the place. Fierce fighting followed in the narrow streets of the little town, but the Russians were forced to cross the bridges, and finally Friedland passed entirely into French possession when the bridges were burned.

While this heavy fighting was taking place to the South of the Mill Stream the Centre and Left of the French Army had carried out the Emperor's order and confined itself strictly to engaging the enemy's attention along the rest of the line. In this way Napoleon neutralised the bulk of Bennigsen's Army and prevented it from reinforcing the left wing before the latter was overthrown and crushed, the Friedland bridgehead seized, and the Russian centre and right cut off from the passages across the Alle. Directly this success was achieved Napoleon was also in a position to attack the rest of the Russian Army in rear.

It was just after 7 p.m. when Napoleon, seeing Friedland was occupied, gave the signal for the general advance in order to deal the death stroke to Bennigsen's trapped and stricken army. In vain did Gortschakov attempt to force his way into Friedland from the North, his troops were beaten back by Dupont and Ney. At the same time the Russians in this quarter were attacked by Mortier's Divisions and Oudinot's Grenadiers, supported by the Fusiliers of the Guard (under General Savary).

Apparently it was not until Friedland and its bridges were in flames that Bennigsen realised the extreme danger in which he stood; when the critical state of affairs dawned on him he sent officers in search of a ford and eventually one was found opposite to Kloschenen. Pushing down some of Gortschakov's troops to hold the high ground overlooking Friedland, to safeguard him on that side, gradually he got away the bulk of the guns and the exhausted Infantry of his Right Wing, the retirement being made easier by the failing light. But the

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Ford was so deep that the gun-teams were partly swimming as they dragged the guns across the Alle and then they had to haul them up the right bank which at that place was almost perpendicular.[1]

The Russians fought heroically when the day was irretrievably lost. No single battalion dreamed of surrendering and when forced to yield the left bank the men jumped into the Alle and swam across, or waded across breast-high, or missed the ford and were swept away and drowned. The French took very few unwounded prisoners.[2] The Russian Army did not disgrace itself, but with the higher leadership so glaringly at fault even the most heroic bravery was of no avail, for courage alone could not compel victory under such conditions.

Opposed to Napoleon and handled as it was it would have required the performance of a miracle before the Russian Army could have gained a victory.

By 10.30 p.m. the success was complete; and under Napoleon this striking triumph was due to Senarmont and his gallant gunners. For the 30 guns in about an hour had achieved what Ney's 15,000 men and Dupont's Division (7,000 strong) were unable to do, and which the Divisions still in reserve probably could not have done, at any rate not so quickly; and there was not a moment to spare if the campaign was to be ended on June 14 by a knock-out blow.

The French Army passed the night on the Field of Battle, the Emperor bivouacking in the midst of his troops[3] who were disposed as follows:—

Lannes, close to the Königsberg road, to the N.W. of Friedland.

Mortier, astride the Alle to the E. of Friedland.

Ney, partly in and partly behind Friedland.

The Guard and Victor (less Dupont's Division) near Posthenen.

Of the troops that Napoleon assembled for the Battle actually 2 of Victor's Divisions as well as the Guard did not fire a shot in the action. Owing to Senarmont the decision was hardly in doubt for a moment and thus the greater part of the Reserve was not required.

Losses.

The losses in this great battle were very severe. The French appear to have lost 2 eagles and about 8,000 men (including 10 Generals); but the Russian losses are very difficult to estimate for the numbers vary in every account, consequently the safest thing to do is to accept the smallest estimate which places them at 17,000, including 5,500 prisoners—only 500 of the latter being unwounded;

[1] Wilson, p. 21.

[2] Actually about 5000 Russians fled down the left bank and finally crossed at Allenburg. It will be remembered that Bennigsen earlier in the day had sent on a detachment to secure this crossing. Grouchy has been severely blamed for allowing any escape on this flank; but it appears likely that the visibility was very poor during the closing scene, owing to the failing light and the cloud banks of smoke that hung over the field, and thus serious cavalry action might have been almost impossible.

[3] The position of Napoleon's bivouac is shown on Map 3.

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of their generals 5 were killed and 2 wounded, and their Army lost 17 guns, some standards and many vehicles.

It was a crushing defeat; not only was the Russian Army out-fought but Napoleon out-generalled it at every point and reaped to the full on the field of Friedland the reward of his bold strategy and magnificent manœuvres. This victory finished the war with a re-sounding clap of thunder.

Conclusion of the Campaign.

(Vide Map 4).

The rest of the campaign can be described in very few words. The bridges over the Alle were at once repaired and on the next morning, June 15, the Grand Army opened the pursuit of Bennigsen's shattered and demoralised army, but the Russians had used the short, summer night to such advantage that they managed to cross the Pregel near Wehlau, without being overtaken by the French cavalry.

Lestocq and Kamenskoi, on hearing of the overthrow of Bennigsen at Friedland, promptly retired to Tilsit abandoning Königsberg, and Soult entered it on June 16.

By June 19 Murat, following on their heels,[1] reached the banks of the Niemen at Tilsit and there received suggestions for an armistice which Napoleon consented to when he reached the place a few hours later. It was ratified on June 22, and the two Treaties of Tilsit were concluded before July was two weeks old.

Thus the Emperor gave the beaten army no respite, when it left the field to save what might still be saved, but he opened an immediate pursuit to make his victory the greater. This pursuit was undertaken not with the idea of any further occupation of territory, but of forcing peace on the vanquished enemy at the sword's point. By an exhibition of energy he knew he would gain a result that it would take another battle to attain if the chance was allowed to slip away. In warfare, as Napoleon understood it,[2] nothing was done so long as anything remained to be done or as long as an enemy was left in the field. His one aim on June 15th, and until the armistice was signed, was to improve his victory in every way.

The war was over, ended by one stunning blow, and well might Napoleon say to his soldiers: "You commemorated at Austerlitz the day of my coronation, and you have now done honour to the anniversary of Marengo by a victory which has finished the war."[3]

(To be concluded).

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[1] Murat, with the experience of Jena fresh in his memory, knew that cavalry alone are capable of cutting the rich harvest of victory with a scythe, infantry can only reap it with a sickle. Clausewitz "On War", ii, 7.

[2] Napoleon's whole doctrine of pursuit is given in the orders he issued to Marshal Soult at 10 p.m. on 3 December, 1805, the day after the Battle of Austerlitz.

[3] Tilsit, June 22. Corr. 12804.

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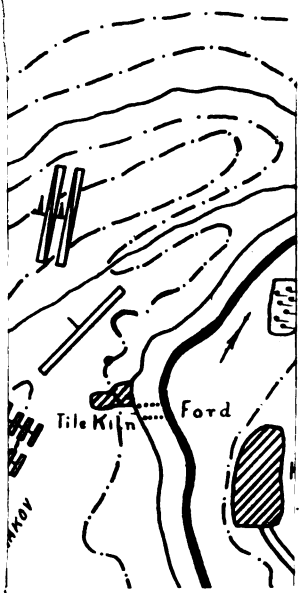
FRIEDLAND,
ABOUT 5 P.M.



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SUGGESTED REORGANIZATION OF SIEGE ARTILLERY.

By Major W. R. Thompson, R.G.A.

At the commencement of the war Siege Artillery was organized in Brigades.

This system broke down during protracted stationary warfare, with its attendant elaboration and complication as regards local orders, communications, etc., because single units had constantly to be transferred from one part of the line to another, and it became necessary to have someone with local knowledge who should remain behind to take over and instruct fresh units on their arrival.

The Group system was then introduced.

This system is unsatisfactory for the following reasons. Groups have little knowledge of or interest in their batteries, which are constantly changing, and have, in many cases, come to regard themselves as telephone exchanges merely passing on to the batteries orders received from the Corps H.A.

The system is obviously inapplicable to moving warfare, and moreover conditions have changed since the system was introduced, the artillery having greatly increased.

What is required at present is a system which will combine the greatest possible economy in regard to the more highly specialized class of individual, without detracting overmuch from the efficiency of the unit, and one which is adapted alike to moving and stationary warfare. These conditions it is thought are more nearly met by the double battery system than any other.

It must be remembered that it will no longer be necessary as in the early days of the war, to move so small a unit as a 4-gun battery.

The double battery would consist of two single batteries of the same nature of ordnance, with a major in command assisted by an adjutant, a regimental sergeant major, a quartermaster sergeant, and (say) 12 other ranks as telephonists, orderlies, etc. Each single battery would be commanded by a captain with 4 subalterns under him. The senior sergeant in each battery would become battery sergeant major.

We thus save on every two batteries, the following personnel: 1 major, 1 subaltern, 1 sergeant major—since the single battery sergeant major need have little knowledge of routine work and interior economy, his duties being merely those of senior sergeant, and one quartermaster sergeant.

The double battery would be in communication with and take its orders direct from the Corps H.A. Commander and the Group would be abolished, saving a large part of its personnel.

I say a large part only as doubtless the Staff of the Corps H.A. would have to be slightly increased to deal with the extra work and

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the personnel for this increase could be found from the abolished groups.

I think the advantages of this system—in many respects very similar to the old brigade system—will be clear to anyone who cares to think about it,—there is no time now to go into details. I will end by suggesting a few advantages as they occur to me—not in their order of importance.

(1). Speeding up of communications—targets more quickly allotted and engaged.

(2). Reduction in establishment of A.O.C. by 1 Artificer per two batteries. One A.O.C. Artificer per double battery would be sufficient.

(3). In the small advances which are becoming general, it will be possible to push the two batteries forward on the overlap principle, thus always keeping 4 of the 8 guns in action during the move and when settled down again one battery would be in advance for long range targets and counter battery work whilst the other would be employed on trenches and nearer targets. By carefully working this principle it should be possible for a Battery Commander to so allot the targets of his task as to fire the least possible number of full charges, and so greatly prolong the life of his guns. Again should one battery come under shell fire from the enemy, the other battery might be able to take on its task or even bring neutralizing fire to bear on the enemy's battery thus mutually protecting one another.

(4). Reduction in the establishment of Light Cars and motor cycles.

It is suggested that the following establishment should be substituted for the present one—side cars are quite useless for the rough work required of them.

Double Battery Headquarters—1 Ford Car, 1 Motor cycle and two horses.

Each Battery—1 Ford Car, 2 Motor cycles and two horses.

It is very strongly recommended that a fast light lorry, such as the present Flying Corps tender should be supplied at the rate of one per double battery. This lorry would be of constant use for collecting stores from Workshops, Ordnance, A.S.C., and R.E. and save the wear and tear to roads and gear which is occasioned by the use of a heavy lorry for these purposes as at present.

(5). It could be so arranged that each new battery coming to the front for the first time should join on arrival one of the older batteries waiting to receive it and form with it a double battery.

This would be of great advantage to the new battery which would thus be saved from many initial mistakes and possible avoidable casualties. Many arrangements for its reception could be made in advance, such as choice of position, arcs of fire, rationing, ammunition, etc., and possibly if time should admit, emplacements, dugouts, observation posts might be commenced or even completed.

There are many other ways in which the new batteries would profit by their connection with older and more experienced ones.

(6). A saving of all those stores (A.F.C. 1098-195) which are duplicated to allow of sections of a battery working separately.

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INTERIOR BALLISTICS.

Simple facts and formulæ.

By Lt.-Col. R. K. Hezlet, D.S.O., *pac.*, R.F.A.

INTRODUCTION.

Ballistics is the science which studies the motion of projectiles. It is divided into *Interior Ballistics* which deals with the circumstances of the motion in the bore of the gun and *Exterior Ballistics* which considers the trajectory after the projectile has left the muzzle. The latter as well as Experimental Ballistics, which is concerned with the obtaining of ballistic data by observation and measurement, is outside the scope of these notes which deal only with Interior Ballistics.

An attempt has been made to collect, in as concise and simple a form as possible, methods which can be readily applied to the solution of some of the ballistic problems which arise in the practical employment of modern artillery.

With this end in view only facts and simple formulæ without proofs are given, the formulæ whenever possible being reduced to percentage rules which are indicated as eminently suitable aids to rapid and easy calculation.

For the same reason that no proofs are given no discussions will be found as to the relative advantages and disadvantages of different features in the design of guns, projectiles, and charges, the object being solely to facilitate calculations for such materiel as may be met with. Such an unorthodox treatment of ballistic methods may be objected to as sketchy but it is decidedly practical and cannot fail to serve a useful purpose if it does nothing more than arouse a thirst for further knowledge.

For the partial slaking of such a thirst should it ensue, the reader must turn to the official text books and other standard works on ballistics. It is fully realized that ballistics is a difficult science and that a more complete study is desirable for those who have the necessary time available to devote to it and are equipped with sufficient preliminary scientific training, but it is hoped that these notes may be of some help to those who are not so situated and yet on occasion are confronted with the necessity for the solution of practical problems in Interior Ballistics.

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1. General.

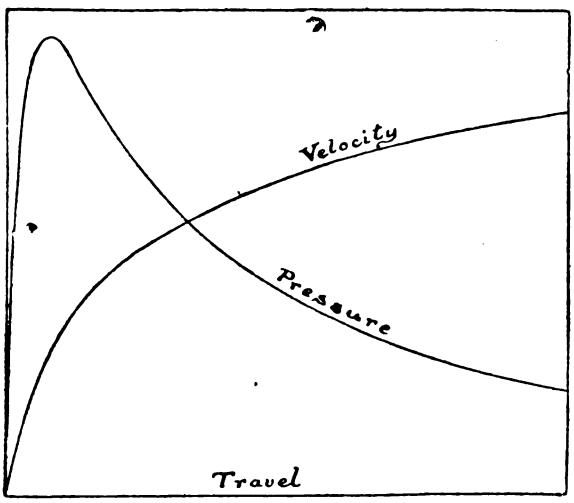
As stated above Interior Ballistics is concerned with the circumstances attending the motion of the projectile in the bore of the gun.

When the charge is ignited gas is evolved from the burning surface, and this gas exerts a gradually increasing pressure on the base of the projectile. When a certain pressure has been developed the projectile starts to move and travels up the bore with continually increasing velocity until it leaves the muzzle of the gun with a certain *muzzle velocity*.

During this travel up the bore the pressure at first increases comparatively rapidly until a certain pressure, the *maximum pressure* is reached. The pressure then gradually decreases to the muzzle, the pressure when the projectile leaves the muzzle being known as the *muzzle pressure*.

Fig. 1 shows diagramatically the corresponding pressure and velocity curves, and may be taken as typical of the general form of these curves for modern colloid propellants in which the grains composing the charge have some more or less definite geometrical shape.

Fig. 1



A charge made up in this way is in practice ignited in the chamber of the gun by means of a small additional charge of black powder, the *igniter* (which in turn has been ignited by the cap, primer, or tube) so that the whole of the surfaces of the grains are set alight or *inflamed* as nearly as possible simultaneously. A characteristic of such propellants is that the grain burns away in concentric parallell layers, and that the rate of burning under constant pressure is uniform.

The greater the pressure the quicker will the grain burn, and it is now generally accepted that the rate of burning may be taken as directly proportional to the pressure.

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Consider now two charges of the same weight made up of (a) comparatively small and (b) comparatively large grains of the same geometrical shape.

For (a) the surface exposed when the charge is ignited (the "initial surface") will be greater than for (b) and the emission of gas will be greater to start with. The pressure and rate of burning will increase comparatively rapidly, and the whole charge will be consumed sooner than in the case of (b). In the case of (b) the total weight of gas emitted will be the same but the mode of emission will be different. The initial surface is not so great, so that at the start, the pressure will rise less rapidly, and the combustion will be completed later. The maximum pressure will occur later and will be less than for (a) but will decrease more slowly.

2. The geometrical form of the grain.

The different forms employed may be divided into three main groups:

(i). Those which burn with a continually decreasing surface. To this group belong all solid grains and short cylinders with an axial perforation.

(ii). Those which burn with a practically constant surface, such as long thin tubes.

(iii). Those which burn with an increasing surface to a certain stage, the grain then breaking up into other forms quite different from the original shape. The only form of this type which we shall consider is a cylindrical grain pierced longitudinally by a number of holes.

3. Combustion under constant pressure.

To get a comparative idea of the way the different forms burn we will now study their combustion under a constant pressure, the rate of burning in this case being, as stated above, uniform, i.e., layers of equal thickness are burned in equal times.

Group (i). Decreasing surface of combustion. Cordite is an example of this group. The charge is made up of a number of cords or "sticks" of circular section, the diameter of the cords being very small in comparison with their length.

If we suppose that the whole surface of the sticks is inflamed practically simultaneously which should be the case if the ignition is properly arranged, it is clear that the whole thickness of the stick will be burnt through before the length of the stick has decreased very much, and in fact the burning at the ends may be practically neglected.

Under these conditions the following table shows the percentage of the whole stick (by weight or volume) consumed corresponding to the percentage of thickness burnt.

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Long cord of circular section.

Percentage of thickness burnt through.	0	20	40	60	80	100%
Percentage of whole grain burnt.	0	36	64	84	96	100%

It will be seen that when 20% of the thickness is burnt through, 36% of the whole stick by weight has already been burnt.

If the long sticks are chopped up into short lengths, the lengths being equal to the diameter, we can no longer neglect the decrease in length of these short cylinders as they burn. In this case the corresponding table would be:

Short cylinder (Length = diameter).

Percentage of thickness burnt through.	0	20	40	60	80	100%
Percentage of whole grain burnt.	0	48.8	78.4	93.6	99.2	100%

So that even more of the grain is burnt for corresponding thicknesses burnt through than in the case of the cord. The burning of the long cord is said to be more "progressive" than that of the short cylinder.

Another form which is sometimes employed is a long flat strip of rectangular section. If the width is say five times that of the thickness we get the following results:

Long strip (Width = 5 times thickness).

Percentage of thickness burnt through.	0	20	40	60	80	100%
Percentage of whole strip burnt.	0	23.3	45	65	85	100%

More progressive than the cord.

If we take a square flat grain of uniform thickness such as might be derived from the strip by cutting it up, we get the following figures:

Square flat grain (Breadth : thickness = 5 : 1).

Percentage of thickness burnt through.	0	20	40	60	80	100%
Percentage of whole grain burnt.	0	26.3	49.2	69	85.8	100%

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Not so progressive as the long strip but more progressive than the cord.

Group (ii). Constant surface of combustion. In the case of a long thin tube of circular section the length being so great compared to the thickness that we may, as in the case of the long cord, neglect the burning of the ends, the surface of combustion will be practically constant throughout the burning, as the tube will burn both inside and out at the same rate. In this case the percentage of the thickness burnt will be equal to the percentage of the whole tube burnt, i.e. when 20% of the thickness is burnt through, 20% of the weight of the tube will be consumed, and so on. This form is therefore more progressive than any of those in group (i), but the long flat strip is not far behind. This is to be expected as we may look on the long flat strip as being the same as a long tube slit down one side and spread out flat.

If however we chop the long tube up into short lengths, say twice as long as they are thick, we get the following results:

Short tube (Length: thickness $=2:1$).

Percentage of thickness burnt through.	0	20	40	60	80	100%
Percentage of whole tube burnt.	0	28	52	72	88	100%

Group (iii). Increasing surface of combustion. As stated above we shall confine ourselves to an examination of one form of grain only, a cylinder with seven equal longitudinal perforations of circular section, the so called "multiperforated" grain. One of the perforations coincides with the axis of the cylinder, and the others are disposed symmetrically about the axis, their centres forming a regular hexagon, and being so arranged that the least dimension of the grain or *web thickness* which is the least distance between any two adjacent circumferences is the same throughout.

By varying the relative proportions of the cylinder and the size of the perforations it can be arranged that the grain burns during the first phase of the combustion (i.e. before the grain breaks up) with a continually increasing surface, a continually decreasing surface, or a surface at first decreasing and then increasing.

In any case when the web thickness is burnt through the grain breaks up into twelve slender triangular prisms with curved sides, known as "slivers". The slivers will burn with a decreasing surface in a very similar manner to the long cords discussed in Group (1).

We will consider more in detail only the case in which the surface increases continually during the first phase of the combustion.

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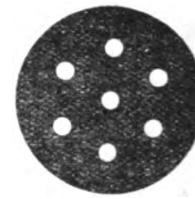
As a typical case take the external diameter say 10 times the diameter of the perforations, and the length of the cylinder 2½ times its diameter. With these dimensions it can be shown that the web thickness is 0·175 times the external diameter.

A cross section of the grain is shown in Fig. 2. For such a grain about 85% of the grain is consumed when the web thickness is burnt through, or the slivers are about 15% of the whole grain, and the corresponding percentage table is—

Fig. 2



Multiperforated grain.

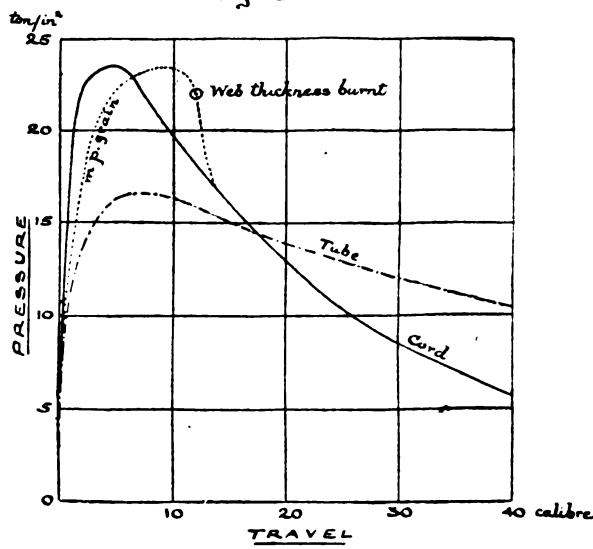
Percentage of web thickness burnt through.	0	20	40	60	80	100%
Percentage of whole grain burnt.	0	14.8	29.9	48	66.2	85%

With this grain then during the first phase of the combustion the percentage of the web thickness burnt through is greater than the corresponding percentage of the whole grain burnt.

4. Combustion of the charge in the gun.

To illustrate the burning of different forms of grain in the gun a diagram Fig. 3 has been prepared.

Fig 3



This shows the *pressure-space curves* for a charge of the same weight made up of long cords, long tubes, and multiperforated grains; the diameter of the cord, thickness of the tube, and web thickness of

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the m.p. grain are so arranged that the whole charge is just completely consumed at the muzzle i.e. after the same travel of the projectile (this is only for illustrative purposes, see sec. 9); the same projectile is supposed to be fired from the same gun with these three different natures of charge.

The muzzle velocity will be the same in each case but the pressure curves very different. For the charge to be completely consumed at the muzzle the diameter of the cord and thickness of the tube will be the same, but the web thickness of the m.p. grain will be considerably less, as after this is burnt through there are still the slivers to burn.

The maximum pressure is lower and the muzzle pressure higher with the tube than with the cord or m.p. grain which are about level in this respect, but the point of maximum pressure with the m.p. grain occurs farther up the bore than with the cord, the point of maximum pressure with the tube being between the two (see also sec. 9).

The point where the web thickness of the m.p. grain is burnt through and the grain breaks up into slivers is shown on the diagram. From this point the pressure drops rapidly, owing to the change from an increasing to a decreasing surface of combustion, until it runs into the curve for the cord which it follows to the muzzle.

If we increase the diameter of the cord and the web thickness of the m.p. grain (keeping the weight of the charge the same) the maximum pressure will be lower but the muzzle velocity will also be lower as the charge will not be completely consumed in the gun.

In practice the maximum pressure is generally the limiting factor as we must not exceed the safe working pressure of the gun, and the endeavour is to get the required muzzle velocity combined with good regularity; for this it is desirable that the muzzle pressure should be low and the charge completely burnt well back in the gun.

The best practicable combination of form and weight of charge for this purpose is the problem of the designer. We will limit ourselves mainly to the ballistics to be expected when the particulars of the charge are given.

5. The main problem of Interior Ballistics.

This may be stated as follows:

Given the necessary particulars of the gun, charge, and projectile to determine the corresponding values of the velocity of the projectile (with special attention to the muzzle velocity), the pressure of the gases of the charge (with special attention to the maximum pressure), and proportion of the charge burnt (with special attention to the point of complete combustion) at any point of the travel of the projectile up the bore.

Various subsidiary problems of an inverse nature required for considering questions of design and analyzing firing results will also suggest themselves.

The physical phenomena as will be readily understood are of a very complex nature. Besides the energy expended in propelling

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the projectile from the muzzle with a certain muzzle velocity we have the work expended on the charge, on the gun and mounting (recoil), and in giving rotation to the projectile; work is also done in forcing the driving band into the rifling grooves ("engraving" the band), and in overcoming friction up the bore. There is also the heat lost by conduction.

As regards the gun besides the main dimensions ("calibre", "chamber capacity", and "shot travel") variations in the design of the rifling and the state of wear of the bore generally may have an appreciable effect on the results. This does not exhaust the possible causes of variation, and in fact two guns of the same design even when new may not give the same muzzle velocity under conditions which have been carefully made as nearly identical as possible.

As regards the charge in addition to the nature of the propellant and form of grain we may have to take into account the circumstances of the ignition and the temperature of the charge as fired. Two samples or "lots" of the same propellant however carefully made to be as nearly identical as possible may give different ballistics in the same gun, and even if they give practically the same results when new the matter may be complicated later by the length and conditions of storage.

As regards the projectile, besides the weight the design of the driving band may have to be taken into account as this may effect its resistance.

It must be understood that though all these causes and others not touched on may appreciably affect the results they by no means all do so in all circumstances; from the point of view of their practical effect on shooting; indeed some of them may require very refined experimental methods to even detect them. For this reason a due appreciation of their relative importance in any particular case is very desirable and can only be obtained by close study and wide experience.

From the extreme complexity of the physical phenomena even under carefully standardized conditions it may be doubted if a complete solution of the problem is possible, but various systems more or less complete for an approximate solution have been proposed and worked out. The underlying theory is of necessity difficult and the calculations involved laborious, the complications increasing rapidly with the degree of comprehensiveness attempted.

No attempt will be made to formulate such a system here. We shall confine ourselves strictly to simple empirical formulæ, by the aid of which, given the muzzle velocity and maximum pressure known to be obtained with certain combinations of gun charge and projectile, we can endeavour to predict the changes in ballistics which will result from variations in the data which give the known results.

6. Notation. The principle of the standard gun.

The following notation will be employed:

d = Calibre in inches.

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The calibre is defined as the diameter of the bore of the gun measured across the lands (the portions of the bore between the grooves of the rifling).

G = Chamber capacity in cubic inches.

That is the volume of the portion of the interior of the gun which is behind the projectile when rammed home. In the case of guns which use a metallic cartridge case allowance must be made for the space occupied by this.

S = Shot travel in inches.

That is the distance moved through by the projectile from the time it starts to move till it leaves the muzzle.

W = Weight of projectile in lbs.

M = Weight of charge in lbs.

L = Least dimension of the grain in inches.

That is the diameter of the cords, thickness of the tubes or strips, or web thickness of the m.p. grains of which the charge is made up.

V = Muzzle velocity in feet per second (f/s).

P = Maximum pressure in tons per square inch (ton/in^2).

In order to facilitate calculations and comparisons of results with guns of different calibres we shall as a rule reduce all particulars to a comparison with those of a standard or unit gun of 1 inch calibre. The reduction of the data to those of the standard gun in any particular case is effected by supposing the gun under consideration, together with its projectile and charge, to be expanded or contracted symmetrically until its calibre is equal to 1 inch. Corresponding to G, S, W, M, and L for the gun calibre d ins. we shall have for the standard gun

$$G_1 = \frac{G}{d^3}$$

$$S_1 = \frac{S}{d^3}$$

$$M_1 = \frac{M}{d^3}$$

$$W_1 = \frac{W}{d^3}$$

$$L_1 = \frac{L}{d}$$

V and P will remain unchanged.

7. Monomial formulæ for muzzle velocity and maximum pressure.

The working formulæ for muzzle velocity and maximum pressure will be based on the assumption that they can be put in the form—

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$$V = K_v G_1^g S_1^s W_1^w M_1^m L_1^l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

$$P = K_p G_1^g W_1^w M_1^m L_1^l \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

Where g, s, w, m, and l are empirical indices positive or negative, integral or fractional, and K_v, K_p empirical constants. The values of the indices denoted by the same letter are different in (1) and (2).

These formulæ are of the monomial type,* and are to be regarded as purely empirical, but with a due appreciation of their possibilities and limitations they will be found very useful working tools.

Assuming, as the result of experience, suitable values for the indices, we can from known firing results (muzzle velocity and maximum pressure) for a certain gun, projectile and charge evaluate K_v and K_p of (1) and (2) by simple calculation with the aid of a table of logarithms. Then by a reverse process, using the values of K_v and K_p so obtained, we can calculate the muzzle velocity and maximum pressure to be expected with another gun, projectile, and charge (of the same propellant made up of grains of the same form), inserting the appropriate values of G_1, S_1, W_1, M_1, and L_1 in (1) and (2).

The following tables have been drawn up as a guide to values of the indices which will be found suitable for guns, at any rate for trial purposes, with the following propellants:

Long cords of cordite M.D. (M.D.)

Long tubes of cordite M.D.T. (M.D.T.)

Short tubes or m.p. grains of nitrocellulose (N.C.T.)

The values of the indices given have been taken (with slight modifications) from those suggested by Captain J. H. Hardcastle.†

Table I.

Indices for Muzzle Velocity.

g	*s*	*w*	*m*	*l*
−0·25	+0·2	−0·4	M.D.T. + 0·7	M.D.T., N.T.C. } −0·3
			N.C.T., M.D. } + 0·6	M.D. − 0·15

* See Appendix.

† *Monomial Formulas* for *Pressure and Velocity* for *Ordnance and Small Arms*, Royal Artillery Journal vol. 42. In this paper the author attempts by an extremely ingenious and somewhat daring manipulation of the more elaborate formulæ of Ingalls and Charbonnier to reconcile them with the simple monomials proposed by Sarrau.

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Table II.

Indices for Maximum Pressure.

g	w	m	l
M.D.T. − 1·00 N.C.T. − 1·10 M.D. − 1·15	+ 0·6	M.D.T. + 1·8 N.C.T. } + 1·6 M.D. }	M.D.T. } − 1·40 N.C.T. } M.D. − 0·85

An example to illustrate the use of these tables will now be given.

Example I. A 6″ gun, chamber capacity 1600 in³, shot travel 250″, fires a 100lb projectile with a charge of 25lb of M.D., dia. of cord 0·2″, giving a muzzle velocity of 2650 f/s with a maximum pressure of 16 ton/in². What muzzle velocity and maximum pressure may be expected from a 5″ gun, chamber capacity 600 in³, shot travel 140″ with a 55lb projectile and a charge of 10lb M.D., dia. of cord 0·12″ ?

For the 6″ gun we have

$$P = 16$$
$$G = 1600 \qquad G_1 = 7{\cdot}4$$
$$S = 250 \qquad S_1 = 41{\cdot}6$$
$$W = 100 \qquad W_1 = 0{\cdot}463$$
$$M = 25 \qquad M_1 = 0{\cdot}156$$
$$L = 0{\cdot}2 \qquad L_1 = 0{\cdot}033$$
$$V = 2650$$
$$P = 16$$

From (1) and Table I

$$V = K_v\, G_1^{-0.25}\, S_1^{0.2}\, W_1^{-0.4}\, M_1^{0.6}\, L_1^{-0.15}$$

or taking logarithms and rearranging (to avoid multiplying negative characteristsics by fractional indices which is troublesome)

$$\log K_v = \log V_1 + 0{\cdot}25 \log G_1 + 0{\cdot}6 \log \frac{1}{M_1} - 0{\cdot}2 \log S_1 - 0{\cdot}4 \log \frac{1}{W_1} - 0{\cdot}15 \log \frac{1}{L_1}$$

$$\log V = 3{\cdot}423 \qquad \log G_1 = 0{\cdot}869$$
$$0{\cdot}25 \log G_1 = 0{\cdot}217 \qquad \log S_1 = 1{\cdot}619$$
$$0{\cdot}6 \log \frac{1}{M_1} = 0{\cdot}562 \qquad \log \frac{1}{W_1} = 0{\cdot}334$$
$$\text{Sum} = A = 4{\cdot}202 \qquad \log \frac{1}{M_1} = 0{\cdot}937$$
$$0{\cdot}2 \log S_1 = 0{\cdot}324 \qquad \frac{1}{L_1} = 1{\cdot}477$$
$$0{\cdot}4 \log \frac{1}{W_1} = 0{\cdot}133$$
$$0{\cdot}15 \log \frac{1}{L_1} = 0{\cdot}221$$
$$\text{Sum} = B = 0{\cdot}678$$
$$A - B = \log K_v = 3{\cdot}524$$

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Similarly from (2) and Table II

$$P = K_p\, G_1^{-1.15}\, W_1^{0.6}\, M_1^{1.6}\, L_1^{-0.85}$$

$$\text{whence } \log K_p = 2{\cdot}645$$

Then for the 5″ gun

$G = 600$	$G_1 = 4{\cdot}8$
$S = 140$	$S_1 = 28$
$W = 55$	$W_1 = 0{\cdot}44$
$M = 10$	$M_1 = 0{\cdot}08$
$L = 0{\cdot}12$	$L_1 = 0{\cdot}024$

and

$$\log V = \log K_v + 0{\cdot}2 \log S_1 + 0{\cdot}4 \log \frac{1}{W_1} + 0{\cdot}15 \log \frac{1}{L_1}$$

$$- 0{\cdot}25 \log G_1 - 0{\cdot}6 \log \frac{1}{M_1}$$

which using the value of $\log K_v$ found for the 6″ gun gives

$$V = 2350 \text{ f/s}$$

similarly using the value of $\log K_p$ found for the 6″ gun we get for the 5″ gun

$$P = 18{\cdot}6 \text{ ton/in}^2$$

It must not be inferred from this that for any propellant we can arrive at values of K_v and K_p and the indices g, s, w, m, l, which will reproduce the firing results in all circumstances. Investigations to determine such fixed values once for all, will soon lead to dissappointment. It must be remembered that we have only embodied in the formulæ differences in calibre, chamber capacity, shot travel, weight of projectile, weight of charge, and dimensions of the propellant. We have not taken into account any of the other causes of variation touched on in sec. 5.

When we analyze firing results by means of (1) and (2) all these neglected factors are as it were embodied in the values of K_v and K_p arrived at, and these values of K_v and K_p and also the values of the indices are only suitable for application in other cases in which the effects of the neglected factors are proportionally similar.

The *density of loading*,* and the position of the point of complete combustion of the charge will also have an influence, and an adjustment of constants and indices may be necessary for widely different densities of loading and according as to whether the charge is completely consumed well back on the gun or whether there is a proportion of the charge still unburnt when the projectile leaves the muzzle.

* The density of loading is defined as the "ratio of the weight of the charge to the weight of a volume of water just sufficient to fill the chamber." This is given by 27.7 .

The greater the density of loading, the less the *initial air space* (the volume of the chamber not actually occupied by the grains of the charge).

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The values of the indices in Tables I and II are adjusted for the average conditions of modern practice,* and if the above warning is kept in mind and the formulæ used in an intelligent manner they will, as already stated be found extremely useful working tools.

If only a few of the data vary it is not necessary to work with the complete formulæ (1) and (2). Thus if we are dealing with the same gun and projectile and the same propellant of the same form and size, and only wish to investigate the effect on the muzzle velocity of differences in weight of the charge, we need not introduce the standard gun and work out the constant Kv but may write

$$\frac{V'}{V''} = \left(\frac{M'}{M''}\right)^m$$

where the muzzle velocity V^1 is known for a charge of weight M^1 and we want to find the velocity V'' for a charge M''. Again if we are dealing with differences in weight of both charge and projectile we may employ

$$\frac{V'}{V''} = \left(\frac{M'}{M''}\right)^m \left(\frac{W'}{W''}\right)^w$$

Some examples of such "short cuts" will now be given.

Example 2. A gun gives m.v. 2500 f/s with full charge 12lbs. M.D.T., what will the m.v. be with a ¾ charge of 9lbs. ?

Here $V^1 = 2500$ for $M^1 = 12$, and we have to find V'' for $M'' = 9$ from

$$\frac{V'}{V''} = \left(\frac{M'}{M''}\right)^{0.7}$$

we have

$$\frac{V'}{V''} = \left(\frac{12}{9}\right)^{0.7} = (1.33)^{0.7} = 1.22$$

Therefore $$V'' = \frac{2500}{1.22} = 2050 \text{ f/s}$$

Example 3. A gun gives m.v. 2000 f/s with an 100lb projectile. By how much must the weight of the projectile be reduced to give m.v. 2200 f/s with the same charge

Here $V^1 = 2000$ for $W^1 = 100$, and we have to find W'' for $V'' = 2200$ from

$$\frac{V'}{V''} = \left(\frac{W'}{W''}\right)^{-0.4} = \left(\frac{W''}{W'}\right)^{0.4}$$

or $0.4 \log W'' = 0.4 \log W' + \log V' - \log V''$

* These indices are suitable for ordnance. For rifles the indices require considerable modification, for values see Hardcastle loc. cit.

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$$\begin{aligned} \log W' &= 2{\cdot}000 \\ 0{\cdot}4 \log W' &= 0{\cdot}800 \\ \log V' &= 3{\cdot}301 \\ & \ 4{\cdot}101 \\ \log V'' &= 3{\cdot}342 \\ 0{\cdot}4 \log W'' &= 0{\cdot}759 \\ \log W'' &= 1{\cdot}897,\ W'' = 79\text{lb nearly} \end{aligned}$$

Example 4. A charge of 100lb M.D., dia. 0·25″ gives V = 2500 f/s, P = 18 ton/in². What is the greatest weight of charge which can be employed without exceeding this chamber pressure if the thickness of the cord is reduced to 0·2″, and what will the m.v. be with the new charge?

We have $V' = 2500$, $P' = 18$, $M' = 100$, $L' = 0{\cdot}25$ and we want to find V'' and M'' for

$$P'' = P' = 18 \text{ and } L'' = 0{\cdot}2$$

$$\frac{P'}{P''} = 1 = \left(\frac{M'}{M''}\right)^{1.6}\left(\frac{L'}{L''}\right)^{-0.85}$$

whence M''

and then

$$\frac{V'}{V''} = \left(\frac{M'}{M''}\right)^{0.6}\left(\frac{L'}{L''}\right)^{-0.15}$$

which gives V''.

$$1{\cdot}6 \log \frac{M'}{M''} = 0{\cdot}85 \log \frac{L'}{L''}$$

giving $\frac{M'}{M''} = 1{\cdot}37$ and $M'' = 73$ lbs.

Then

$$\log V'' = \log V' + 0{\cdot}15 \log \frac{L''}{L'} - 0{\cdot}6 \log \frac{M'}{M'}$$

$$\text{whence } V'' = 2360 \text{ f/s.}$$

8. Percentage Formulæ.

When the variations in the data are comparatively small the monomial formulæ may be replaced by a simple percentage approximation which will give sufficient accuracy while reducing the calculations to little more than easy mental arithmetic. The following tables derived from the indices already employed with the monomial formulæ give the information necessary for such percentage calculations.

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Table III.

Percentage alteration in Muzzle Velocity due to an alteration of + 10% in				
Chamber Capacity.	Shot Travel.	Weight of Projectile.	Weight of Charge.	Least Dimension of grain.
−2·5%	+2%	−4%	M.D.T + 7% N.C.T. M.D. } +6%	M.D.T. N.C.T. } −3% M.D. −1.5%

Table IV.

Percentage alteration in Maximum Pressure due to an alteration of + 10 % in			
Chamber Capacity.	Weight of Projectile.	Weight of Charge.	Least Dimension of grain.
M.D.T. −10% N.C.T. −11% M.D. −11.5%	+6%	M.D.T. +18% N.C.T. M.D. } +16%	M.D.T. N.C.T. } −14% M.D. −6.5%

Example 5. A gun gives m.v. 1680 f/s for max. press. 15·5 ton/in² with a charge of 20lb N.C.T. What decrease in charge will give a velocity of 1660 f/s and what will be the corresponding pressure?

A change from 1680 to 1660 f/s is a decrease of 1·19 %. From Table III a decrease of 10% in wt. of charge will decrease m.v. 6%. Therefore a decrease of 1·19% m.v. will correspond to decrease in weight of charge of $\frac{10 \times 1{\cdot}19}{6} = 1{\cdot}98\%$ or 0·396lb.

From Table IV 10% decr. in charge decr. P by 16%. Therefore 1·98% decr. in charge decr. P by 3·16% = 0·49 ton/in². Hence the maximum pressure for V = 1660 f/s will be about 15 ton/in².

Working out the examples in the previous section by Tables III and IV will show the difference in results when the complete monomial formulæ and the percentage approximations are employed.

9. The position of the point of maximum pressure and of complete combustion of the charge.

The travel in calibres to the point of maximum pressure is given approximately for long cords or short tubes by

$$0{\cdot}365\ (1{\cdot}57\ G_1 - 27{\cdot}7\ M_1)$$

The corresponding expression for long tubes is

$$0{\cdot}485\ (1{\cdot}57\ G_1 - 27{\cdot}7\ M_1)$$

and for m.p. grains

$$0{\cdot}647\ (1{\cdot}57\ G_1 - 27{\cdot}7\ M_1)$$

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Considering the point of complete combustion or distance the projectile has travelled when the charge is all consumed there are three possible cases.

(i). The charge may be completely consumed some time before the projectile leaves the muzzle.

(ii). The charge may be exactly consumed at the instant the projectile leaves the muzzle.

(iii). The charge may be still burning when the projectile leaves the muzzle.

(i). Is the most desirable state of affairs from the point of view of regularity in the ballistics (small differences in m.v. for successive rounds and moderate temperature correction). Up to the point of complete combustion fresh gas is being continually emitted from the burning surface of the charge. After this point there is no fresh emission of gas and the pressure depends only on the expansion of the gas already evolved; the pressure will consequently fall off more rapidly. The point of complete combustion should then be arranged to be as far back as possible consistently with obtaining the required m.v. without exceeding the safe working pressure of the gun.

(ii) and (iii). Are only permissible when the required m.v. cannot be obtained in any other way without exceeding the safe working pressure. In fact (iii) at any rate must be looked upon as a make-shift expedient necessitated by faulty design or resorted to for the purpose of utilizing an unsuitable size of propellant, or for obtaining a higher m.v. from the gun than that for which the design is suitable.

The determination of the point of complete combustion for a given charge is not a simple matter but the following method may be employed to give an indication as to whether a charge for which V and P are known is completely consumed in the gun or not.

Calculate

$$q = \frac{1{\cdot}235\ S_1}{1{\cdot}57\ G_1 - 27{\cdot}7\ M_1}$$

and

$$B = \frac{QW_1V^2}{100{,}000\ (1{\cdot}57\ G_1 - 27{\cdot}7\ M_1)}$$

where Q is the value given in Table V for q, and V is the known value of the m.v.*

If B is less than the known value of P the combustion of the charge is complete before the projectile leaves the muzzle.

If B is greater than the known value of P the combustion of the charge is not complete when the projectile leaves the muzzle.

* It can be shown that q is the number of expansions of the initial air space when the projectile leaves the muzzle. B is the value (using a modification of Ingalls' method) of the maximum pressure for the given *m.v.* if the charge were exactly consumed at the muzzle.

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Table V.

Values of Q.

q	Long cords.	Short * Tubes.	Long Tubes.	M.P. Grains.
1	14·4	14·5	14·5	13·2
2	9·25	7·38	7·31	6·25
3	7·06	5·23	5·15	4·29
4	5·86	4·19	4·11	3·37
5	5·14	3·57	3·49	2·82
6	4·62	3·17	3·07	2·47
7	4·24	2·85	2·77	2·24
8	3·95	2·62	2·55	2·05
9	3·73	2·45	2·37	1·89
10	3·45	2·30	2·22	1·75
11	2·37	2·18	2·10	1·65
12	3·22	2·07	2·00	1·56
13	3·10	1·98	1·91	1·49
14	2·98	1·90	1·83	1·43
15	2·88	1·83	1·76	1·37
16	2·79	1·77	1·70	1·32
17	2·71	1·71	1·65	1·28
18	2·65	1·66	1·60	1·24
19	2·59	1·62	1·56	1·20
20	2·54	1·57	1·52	1·17

Example 6. A 3″ gun ($G = 160$ in^3, $S = 120''$, $W = 12{\cdot}5$ lb) gives the following results:

(a). $V = 2525$ f/s, $P = 14{\cdot}5$ ton/in^2 with $M = 2{\cdot}6$ lbs. of MDT of a certain size.

(b). $V = 2610$ f/s, $P = 17{\cdot}0$ ton/in^2 with the same weight of charge but of M.D. of a certain size.

To find whether the charges (a) and (b) are completely consumed at the muzzle.

We have $G_1 = 5{\cdot}92$, $S_1 = 40$, $W_1 = 0{\cdot}464$, $M_1 = 0{\cdot}0962$

$$\begin{aligned} 1{\cdot}57\ G_1 &= 9{\cdot}30 \\ 27{\cdot}7\ M_1 &= 2{\cdot}66 \\ \text{diff.} &= 6{\cdot}64 \\ 1{\cdot}235\ S_1 &= 49{\cdot}4 \\ q = \frac{49{\cdot}4}{6{\cdot}64} &= 7{\cdot}44 \end{aligned}$$

* Length 15 times thickness.

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(a). From Table V for long tubes for $q = 7{\cdot}44$, $Q = 2{\cdot}67$

$$B = \frac{QW_1V^2}{100{,}000\,(1{\cdot}57\,G_1 - 27{\cdot}7\,M_1}$$

$$= \frac{2{\cdot}67 \times 0{\cdot}464 \times (2525)^2}{100{,}000 \times 6{\cdot}64}$$

$$= 11{\cdot}9 \text{ ton/in}^2$$

which is less than P.

Hence the M.D.T. charge is completely consumed at the muzzle.

(b). From Table V for long cords for $q = 7{\cdot}44$, $Q = 4{\cdot}11$

$$B = \frac{4{\cdot}11 \times 0{\cdot}464 \times (2610)^2}{100{,}000 \times 6{\cdot}64}$$

$$= 19{\cdot}6 \text{ ton/in}^2$$

which is greater than P.

Hence the M.D. charge is not completely consumed at the muzzle.

10. Charge Temperature.

The general effect of the temperature of the charge on the ballistics is that the higher the temperature the higher the m.v. and maximum pressure and the sooner is the charge consumed. Hence the importance in comparing ballistic data of determining them at the same charge temperature or of knowing the charge temperature for which they were determined and the *temperature correction*, which is generally expressed as the alteration in V and P due to a certain alteration in the charge temperature.

With a charge which is burnt well back from the muzzle the effect of the charge temperature may under certain conditions be so small as to be negligible for ordinary temperatures, while with a charge which is not all burnt at the muzzle at all temperatures the correction will tend to be comparatively large and irregular.

No simple reliable rule can be given for estimating the temperature correction from the particulars of the gun, projectile and charge. This has to be determined by actual firing at different charge temperatures.

APPENDIX.

MONOMIAL FORMULÆ.

The equation

$$y = a\,x^n \qquad (1)$$

is typical of the monomial formulæ, where the index n may be positive or negative, integral or fractional. For practical calculation (except when n = 1or 2) we employ logarithms and transform (1) into

$$\log y = \log a + n \log x \qquad (2)$$

For small differences in x and y equation (1) is equivalent to the statement that 1% increase or decrease in x causes n% increase or

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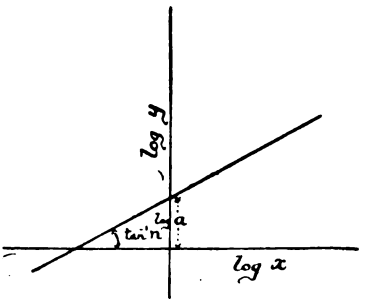
decrease in y. This explains the connection between the indices in Tables I and II of sec. 7 and the percentages in Tables III and IV of sec. 8.

If we plot corresponding values of x and y for a given a and n, the points will be on a curve except when $n = 1$ (when the graph will be a straight line passing through the point $x = 0$, $y = 0$, and inclined to the axis of x at an angle whose tangent is a).

If however we take (2) and plot log x and log y instead of x and y, the points will always lie on a straight line no matter what the value of n, and the angle which this straight line makes with the axis of x will now be the angle whose tangent is n and log a will be the distance from the origin at which the straight line cuts the axis of y, sec. Fig. 4.

Fig 4



The reverse process is the usual case where we have a number of corresponding values of x and y determined by experiment and wish to see if they can be approximately represented by a formulæ of the type

$$y = a\,x^n$$

and if so what will be a suitable value for n.

For the plotting, paper with squares ruled in logarithmic proportion is sometimes employed, but ordinary squared paper is quite suitable, log x and log y being plotted on a convenient scale.

Fig. 5 shows the plotting by this method of a number of firing results (muzzle velocities) for a certain gun with different weights of charge, all the other particulars being kept the same.

The firing results plotted were:

M lbs.	6.12	6.62	7.69	8.0	9.0	10.25	11.0
V f/s	816	865	959	991	1071	1164	1222

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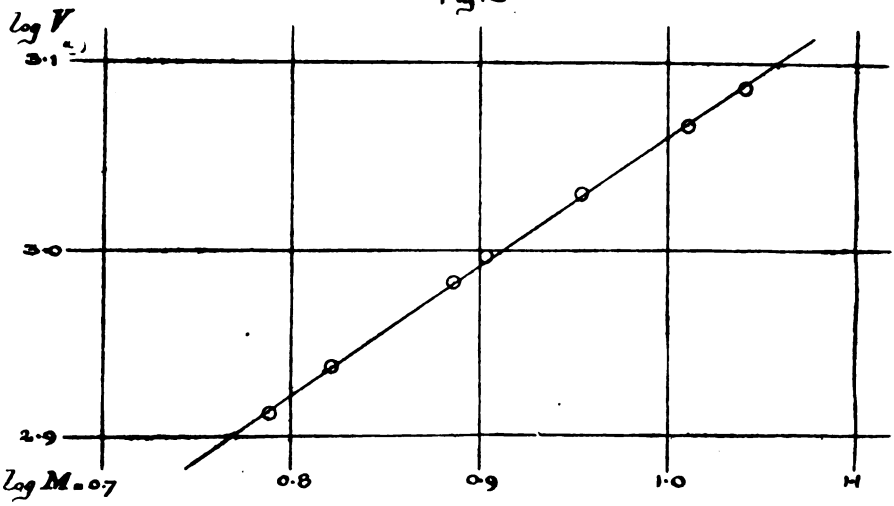
The points obtained are shown by the small circles.

It is then clear that a straight line as shown on the diagram can

Fig. 5



be drawn which will pass very nearly through all the points. The *best* straight line could be determined mathematically by the "method of least squares" but in practice all that is necessary is to take a piece of thin black thread and move it about on the diagram estimating the best position by eye. Drawing the best straight line determined in this simple manner we can read off the index n. In the present case we thus arrive at the result that

$$\frac{V'}{V''} = \left(\frac{M'}{M''}\right)^{0.7}$$

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PRÈCIS OF MEMORIAL DE ARTILLERIA.

By Major R. H. R. Benson, R.A.

January, 1917.

The Fortifications of Rumania.

A description of the fortifications of Bucharest and of those of the Frontier along the Sereth, with their fixed armaments. These were planned and commenced before the introduction of H.E. shell, and were completed before Engineers had at all realized the power of these shell. They were never modernised, and were practically out of date before the commencement of the present war. Artillery on the other hand has made rapid and steady progress in the last 30 years, and at the moment has undoubtedly established its mastery on the field of battle.

Aerial observation of Fire.

Difficulty of the work and importance of mutual understanding between observer and B.C. Hence the desirability of attaching observers to Brigades of Artillery. Remarks on the various duties which aviators may have to carry out, and a proposed programme for the instruction of observers.

Forces sustaining aeroplanes in flight, (continuation of previous article). Centre of pressure on the wings, and how it moves according to the inclination of the aeroplane to the horizontal. Conditions necessary for longitudinal equilibrium—for lateral equilibrium. Forces acting on the aeroplane when turning. Effect of wind on the aeroplane's course.

February, 1917.

Light Howitzers and Heavy Field Artillery.

(1). Historical—showing that the use of Heavy Artillery in the Field dates back almost to the time at which guns were first mounted on wheels, and that Gustavus Adolphus used both light field pieces and heavy batteries in 1631, and both types were habitually used up to the days of Frederick the Great, 1757. After this heavy artillery

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disappeared temporarily from the field of battle, all the guns in use during the Napoleonic wars and the campaigns of 1859 and 1865 being approximately of the same weight and mobility. Napoleon's batteries in 1803 consisted of 6 guns and two howitzers: this is the first appearance of the light Field Howitzer which however dropped out of use in the campaign of 1866. After the campaign of 1870 improvements in propellants resulted in the production of guns with flat trajectories and this led to the re-introduction of light field howitzers for the attack of troops behind earthworks. T and P fuzes introduced in 1883 greatly increased the effectiveness of shrapnel fire, made movements in the open within range of the hostile artillery very costly and led to the development of field fortifications, and this again stimulated the development of Field Howitzers, which play an important part in the Graeco-Turkish war of 97, and in all subsequent campaigns. Appearance of heavy Howitzers and guns in the field during the Russo-Japanese and South African wars.

(2). The case for the light Field Howitzer and for Heavy Field Artillery—both are necessary to supplement the Field gun in attacking targets which the latter cannot reach either because they are out of range or behind cover. Comparison of the effectiveness of fire against various targets at different ranges of the 75 mm. and 120 mm. Field guns, and shows that at 6000 metres the 120 mm. gun will get as many hits on the target with 11 rounds in 2 minutes 12 seconds as the 75 mm. will get with 100 rounds in 5 minutes. Various other comparisons are given, and show generally that, especially at long ranges, a given effect can be more quickly and economically achieved by a big gun than by a small one, and that the use of the larger gun results in a considerable economy of transport for ammunition supply. The small gun however has the advantage at short ranges.

Discusses the employment of the various sizes in the different phases of an action, and shows how essential it is to have both light and heavy guns and howitzers to perform the varying tasks which are demanded of the artillery. Notes on artillery versus artillery—the use of H.E. shell with time fuzes.

Necessity for special pieces for Anti-Aircraft purposes.

Notes on the different projectiles and their uses.

A number of tables are appended, showing the natures and characteristics of the artillery equipments of various armies from 1803 onwards—tables of comparative efficiency, probable effect, etc., etc.

March, 1917.

Light Howitzers and Heavy Field Artillery.

Discussion as to the number of pieces of artillery required for a division (a) in war of movement and (b) in war of position; the writer advocates, for a Division 15,000 strong, 120 pieces under (a) and under (b) the same plus a special allowance of heavy guns (6-inch) and heavy Howitzers (6-inch up to 20-inch!) and trench mortars.

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A.A. guns are not included in the above. Notes on ammunition requirements, showing the enormous quantities required under present day conditions where heavy bombardments prepare the way for infantry attacks and 'barrages' are put up both for attack and defence. This heavy firing also necessitates the provision of large numbers of spare guns. A description, with photographs, of the Spanish Heavy Artillery—6-inch Howitzer, 4·8 inch gun, 6-inch guns (Krupp and Schneider). Notes on the various types of guns and Howitzers produced by the big Armament Firms in France, Germany and England.

The problem of new Armament for the Spanish Army.

The proposal at present before the country involves the provision of a variety of guns ranging from 13-pounders to 9·2 and 12-in. Howrs., involving great complication from every point of view—tactical as well as administrative and manufacturing. The writer advocates the adoption of some simpler scheme, discusses the possibilities of reducing the number of different calibres and concludes that all requirements of the Field army can be met by 3-inch guns and 6-inch guns and Howitzers, while the siege train should supply heavier Howitzers (24 and 30 cm.) for use when required.

A short note, with two photographs of a motor excavator used for digging trenches on the French front.

Submarines and Coast Defence.

A discussion of the possibilities of the submarine for coast defence, quoting examples of their use for this purpose in the present war, (a) by the Germans for the protection of the Belgian coast, (b) by the Austrians for the defence of Cattaro and (c) by the Germans to assist the Turks in the defence of the Gallipoli peninsular, and showing that in each case the submarine succeeded in ultimately driving off the capital ships of the attack. The author considers that submarines alone cannot be depended upon for the defence of a coast line, but that they undoubtedly furnish the defence with a new weapon of proved efficiency and tremendous potentialities.

Light Howitzers and Heavy Field Artillery.

(Conclusion of previous articles).

Notes on various Fuzes: the Krupp mechanical 25 second time fuze: the Armstrong graze fuze, the Ehrhardt graze and time and percussion fuzes: the Krupp T & P fuze. The organisation of Light Howitzer Batteries and Heavy Batteries in various armies at the outbreak of war. A general resumé of the accepted principles governing the tactical employment of Light Howitzers and Heavy Field Artillery at the outbreak of the present war.

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April, 1917.

Conclusion. The two outstanding lessons of the present war so far as Artillery is concerned are (a) the usefulness of the Light Howitzer as a complement to the light Field gun, and (b) the dominating importance of Heavy Artillery, both guns and howitzers, both in war of movement and war of position, both in attack and defence; and the minor lessons of the war are the importance of aerial observation of fire and the advantages of motor transport for ammunition supply.

Military Industries. The present war shows the enormous importance of industrial strength to a belligerent. Spain is industrially undeveloped and depends on foreign countries for many essential supplies, although she possesses within her boundaries most of the essential raw materials. The writer makes an appeal for the development of Spanish manufactures so that the country may be as nearly self supporting as possible in regard to military requirements should she find herself at war.

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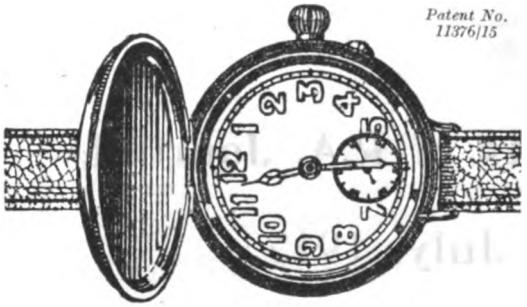

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FRIEDLAND, 1807.

By Major A. F. Becke, late R.F.A.

Part IV. Comments on the Battle.

"*La critique est aisée; mais l'art de la guerre est difficile*".

IT will be recollected that the situation of the French Army on the evening of June 13 was broadly that it manœuvred in two Wings—

Left Wing—Murat, Soult and Davout;

Right Wing—Lannes, with the addition if necessary of Grouchy, Nansouty and Mortier;

And a Reserve under the Emperor's own hand—of Ney, Victor, La Houssaye and the Guard; the Reserve being available to act in either direction according as the circumstances should demand. Thus the Emperor was ready for any manœuvre on Bennigsen's part should the Russian General attempt to retake the offensive between the Alle and the Pregel.[1]

In a sense Friedland was an encounter battle, but in no sense was it an accidental battle. The encounter had been foreseen and arranged, and when Bennigsen's Army finally crossed to the left bank of the Alle at Friedland, Napoleon seized the opportunity, closed with it and engaged it at once.

The battle that resulted remains as a model for an offensive battle delivered on a rapidly conceived but well formed plan and waged on ground that was only reconnoitred during the action. The result was never in real doubt for a moment; and the moral result of the crushing victory that was obtained far outshone the material result obtained on the battlefield itself. The Russian Army was beaten in the field, with the direct result that the nation became demoralised and the campaign was at an end.

After the bloody and inconclusive fight at Eylau, after the long months of waiting, after Bennigsen's recoil at the opening of the Summer campaign and the inconclusive action at Heilsberg, the decision was obtained after four more days of manœuvring; and on the anniversary of Marengo the Emperor gave that battle a worthy sister in Friedland.

Friedland was a really Napoleonic battle.[2] The advance to the field was covered by a General Advanced Guard (Lannes' Corps) whose duty was to screen, reconnoitre and prepare. This Advanced Guard fought the preparatory action, which held the enemy to his

[1] The arrangement of the Grand Army late on June 13th is very similar to its disposition on the eve of Jena—when Lannes also commanded the Advanced Guard and Murat and Davout also formed part of a Wing.

[2] I do not mean that Napoleon's great battles were all fought on the same plan; they were not.

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ground and confused the Russian General about the exact point where he was really threatened. When the General Action commenced the Russian Army was gripped firmly along the front so that Napoleon might break it at one, the vital point, opposite to which the Emperor had arranged the Grand Army, mass disposed in depth, ready to intervene at the critical moment and compel victory by one tremendous blow. The formation of the Grand Army at Friedland exemplifies the present day teaching,[1] "The object will usually be to "concentrate as large a force as possible against one decisive point "to deliver the decisive attack, while the remainder is employed to "prepare for this attack, by attracting the enemy's attention, holding "him to the ground and wearing down his power of resistance;" and "later in the same manual it is stated, "the force allotted to the "decisive attack must be as strong as possible".

The most casual glance at Map 3 shows that Bennigsen formed up in a purely conventional way, paying no heed to the ground or situation. On the other hand the Grand Army was arranged very differently, the mass of the reserve being disposed opposite to that point where the decisive attack was to be made.

Lannes' Advanced Guard action deserves unstinted praise.[2] His duty was clear, it was to gain the time, the space and the information to enable the Emperor to fight a decisive action in front of Friedland. Lannes had no mental misgiving or reservation, despite the fact that he was confronted by the Russian Army. He attacked as the surest way of holding Bennigsen to his ground and preventing the initiative passing into the hands of the Russian General. His bold action imposed on Bennigsen, and his skilful handling of his weak force and the able use he made of the ground deceived the Russian Commander; and his preparatory action remains as a masterpiece for all time. Lannes' difficult task was simplified slightly by the fact that he knew Napoleon and his methods intimately; he knew the Emperor was pressing the march of the Grand Army to the field, that this was only a preparatory action and in due course Napoleon would engage the whole mass in a fight to a finish; therefore he could and did engage his last man, his last horse and unlimber his last gun to carry out the task allotted to him. Further his flanks were not in serious danger. His left (or Northern) flank was certainly in the air, but to turn it would only place Bennigsen further from the Friedland Bridgehead and his only possible retirement would be on Allenburg. Also if it was beaten in Lannes would be forced back in the direction of the Grand Army and probably nothing very untoward would occur; as for his right (or Southern) flank it was obviously covered by the direction of Napoleon's advance. If Bennigsen drove it in and followed up his success, then the Russian Army would be drawn right across the advance of the Grand Army and Lannes would have facilitated a death thrust to the Russians.

This idea leads us naturally to Colonel Michel's suggestion[3] that

---

[1] F.S. Regns., Part I., Chap. VII., "The Battle."

[2] Napoleon's recorded judgment of Marshal Lannes runs as follows:—"I found him, a pigmy; I lost him, a giant." ("*Journal of Las Cases*," ii, 9—*London*, 1823).

[3] Pp. 42, 43.

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as Lannes ran such an obvious risk in front of Bennigsen and the whole Russian Army during his Advanced Guard action on June 14, the French Marshal might have handled his troops differently. The essential was to bring on the decisive battle and to place Bennigsen in the most hazardous position. To carry out this aim Lannes might have adopted Rear Guard rather than Advanced Guard Tactics, have fought a yielding fight, retiring in the direction of Heinrichsdorf and Königsberg and drawing Bennigsen after him.[1] At the same time he would have reported the situation and his intention to Napoleon at Eylau, and also to Davout and Murat, whom he knew were behind him on the Königsberg road. Manœuvring in this way Lannes ran no risk of being crushed; at the same time he gave ample time to Napoleon to arrive with the Grand Army and attack Bennigsen's flank as the Russian Army was drawn across the head of the French advance. Then, when Napoleon was ready to engage, Lannes would have stood his ground, supported by the arrival in succession of Murat and Davout, and Bennigsen would be held fast along his front, whilst Ney, Victor, Mortier and the Guard struck from the South as they deployed in line of battle and forced the Russian Army back on the difficult tract of woodland country between it and the Pregel. Developing in this way it appears the action would have been more certain and less risky, and would have led to a swifter and more crushing disaster than even Friedland proved to be. Also this was undoubtedly the battle that Napoleon foresaw and prepared for on June 13; but it would have been completed on June 15 instead of the 14th.

The plan is entirely in accord with the idea underlying the handling of a General Advanced Guard in that era and also it is in accord with the Emperor's desire to finish the campaign (Corr. 12733); and it is not purely imaginative, for Bennigsen's feeble character made him peculiarly liable to be overpowered by a leader of Lannes' indomitable personality.

For Marshal Lannes to act in this independent way he must have been admitted to Napoleon's confidence, and this method of exercising supreme command was not the one adopted by Napoleon. Just as Davout had failed to appreciate the full significance of the situation on June 6th and actually had assisted to warn Bennigsen,[2] so on June 14th Lannes did not attempt to draw Bennigsen well out of Friedland, but held him in play there until Napoleon and the Grand Army arrived on the ground; and when due weight is given to the orders he received and the situation as he knew it then it is inconceivable that he could have acted in any other way.

To-day the yielding fight that he might have fought would have been far easier, owing to the increased power of modern quick-firing guns and magazine rifles together with the introduction of indirect

[1] If Lannes found that Bennigsen refused to be drawn away from the Alle then he must have had recourse to the tactics that he actually employed; but Bennigsen's immobility would have reassured him about the ultimate safety of his Corps.

[2] Vide p. 38, (Part I).

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laying and of smokeless powder, also to the fact that cavalry are now real mounted riflemen. Consequently an Army Corps supported by one or two cavalry divisions should be able to keep very superior forces in play for at least 24 hours. Also the length of time that many modern battles last gives time for outlying detachments to be recalled to the field and take their part in the action, and motor cyclists, telephones and telegraphs keep them in close touch with the Commander-in-Chief. On the other hand if the Russians had possessed command of the air then their aeroplanes might have been able to warn Bennigsen of the approach of heavy columns from the southward and thus have given him timely warning of the tremendous risk he would be running if he made any considerable advance along the Königsberg road.

Another interesting point about Friedland has been raised by Commandant de Cugnac;[1] for, as he points out, Friedland was actually fought on the idealised plan for Marengo which the Emperor left to posterity in his account of that battle. In 1805 Napoleon corrected the description of the battle of Marengo that was to be published; and in the amended account it was stated that the French retirement from Marengo was voluntary and that the French left and centre fell back, pivoting on the right, which maintained its ground at Castel Ceriolo. Thus, at the crisis, after the Austrian advance had been routed by Marmont's guns, Kellermann's cavalry and Desaix's infantry acting in co-operation, the French right at Castel Ceriolo found itself nearer to the bridges over the Bormida on the Austrian line of retirement than the enemy were, and Desaix's onslaught was the signal for the French Division at Castel Ceriolo to seize the bridges; the result being an Austrian disaster.

But this description does not represent exactly what happened. In the French retirement, which was not voluntary, the Division occupying Castel Ceriolo fell back in sympathy with the rest of the line, and at the crisis it was the unforeseen attack of Desaix's division, prepared by Marmont's guns and coupled with Kellermann's fine charge that caused a wild disorder in the advancing Austrian Army, and then panic broke out and prevented any further serious resistance. Beautiful as the conception is, the Castel Ceriolo pivoting manœuvre is a myth.

But in the same year (1805) as this revised project saw the light, was fought the great battle of Austerlitz; and there we do find this plan of the Emperor's being used in reality. At Austerlitz there was a pivot on the French left—the fortified Santon—the right was the open flank that the Russians and Austrians must attack, and a reserve under Davout was due to arrive there in time for the action. The parallel is very close between the actual plan for the Battle of Austerlitz and the published (and amended) plan for the Battle of Marengo. Actually at Austerlitz the Russian centre was pierced, and then the troops engaging the French right were attacked in flank. Here is illustrated the very stroke that the Emperor had desired to connect with Marengo.

The Battle of Friedland illustrates the idea even more closely. When he reached the field almost Napoleon's first words were, "It is

[1] *"La Campagne de Marengo," pp. 239-244.*

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the anniversary of Marengo". Here the Russian Army was adventured beyond the Alle, the bridges across which lay at Friedland; the French left would neutralise the enemy whilst the French right broke into Friedland and seized the bridges. The result we know. Friedland was as decisive as Marengo or as Austerlitz; due, in this case, to the successful offensive against the Alle Bridges; and despite the difference of ground and numbers it is something more than mere fancy that recognises in the idealized conception of Marengo the undoubted ancestor of Austerlitz and of Friedland.

In his first detailed reconnaissance Napoleon saw the dangerous defects in the Russian position and immediately he formed a simple plan to achieve the destruction of Bennigsen's Army.

It is recorded that when it was realised how long it would take the French Reserve to reach the Battlefield and what little time there was left to complete the victory that day, some of his generals urged the Emperor to defer the decisive phase of the Battle until the morrow. But by this time Napoleon had appreciated the situation and the vital mistake Bennigsen had made; consequently he answered, characteristically enough, "No! No! One does not catch an enemy twice making this blunder". Napoleon knew well that Fortune is a woman, and if the chance she offers to-day is allowed to slip then probably she will not be found so complaisant on the morrow.

To drive in the Russian left promised the greatest results, but it was difficult to accomplish. Before reaching Friedland the French had to advance about 2500 yards through a funnel-shaped opening constricted by the Alle and the Mill Stream. This gap was strongly held, and Russian batteries on both banks could cross fire and cover the gap, whilst enfilading any attacking troops. Victory, in the time available, was only possible if close artillery co-operation was forthcoming on the French side, for the difficulties were precisely those difficulties that only artillery could overcome.

It was Senarmont who recognised how artillery should be handled to attain the desired end, and it was Senarmont who handled his guns so audaciously in their brilliant adventure. If the conception was admirable the execution was beyond all praise.

There is no doubt that the gunner takes an especial interest in Friedland for in this battle he recognises the birth of modern field artillery tactics; and Senarmont's handling of his guns calls for comment. Such action would have been impossible before the artillery drivers had been enrolled as soldiers,[1] but by 1807 the French batteries were really mobile and they could be trusted to carry out precise movements under fire as well as on the parade ground.

Another point was that in the Grand Army combined tactics were a reality; also as a result of the grouping of Divisions into a Corps, the artillery was not all scattered as divisional artillery, but being at the disposition of the Corps Commander all the artillery with the Corps could be massed if necessary; consequently the

[1] This took place in the French Army in 1800. We had forestalled them, for this change occurred in 1794 in our Army.

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Commander of the Corps Artillery could intervene effectively in the general action. These changes and developments gave Senarmont his chance and profiting from the bitter experiences of Eylau and Heilsberg he determined to use his guns in a way previously unknown.[1] Luckily for the success of this experiment the Commander-in-Chief was himself a great artilleryman as well as being the finest soldier of all time and Senarmont's manœuvre appealed to him at once. Nothing but glory could be the guerdon of artillery handled by Senarmont under the sympathic gaze of his master.

The day was coming to an end, Ney's attack had failed, and if a great victory was to be won it had to be gained quickly. Guns were obviously required to give the closest support to the attacking infantry, to enable them to overcome the difficulties that confronted them and to open a way for them through the Russian masses that stood between them and the Friedland bridges. Senarmont's ready grasp of the situation and his bold use of his guns reduced to a minimum the time limit of the Russian endurance, shattered their left wing, which was then rendered incapable of meting out sufficient punishment to stop the advance of Ney and Dupont.

It was a salient moment in the evolution of the tactics of Field Artillery. At last it was able to manœuvre independently and handled by a great Gunner it played a decisive part in the attack. mastered the hostile batteries, smashed up the infantry line itself and, breaking it, opened a way for its own infantry to place the crown on its great tactical achievement. Senarmont had taken for his motto, "The greater the difficulties of our infantry the closer and the more intimate must be the support accorded by our Artillery". Senarmont's manœuvre emphasises, what is so apparent to-day, that both the technical training of the *personnel* of the Battery and the tactical handling of the guns are interdependent, and must be so if the arm is to be strikingly successful on the battlefield and if the Battery is to be used by its commander as a single weapon of many barrels to hit, to hit at exactly the right time and to hit with annihilating effect.

Senarmont unfailingly selected the correct target to engage. At first he employed his 30 guns in counter-battery work, and concentrating them in turn on the dispersed Russian batteries he silenced their batteries by a heavy converging fire from his superior number of guns. Then limbering up he went into deadly range and blew away the Russian infantry with his case-shot.

Senarmont had confidence in himself, in his subordinate officers and in the men; he dared greatly because he had studied and appre-

[1] In the Battle of Eylau, on the morning of February 8th, the VII Corps (Auguereau's), when advancing to the attack, lost its direction in a heavy snow storm and came suddenly under the massed case-shot fire of the central Russian Battery. After this reception, for all practical purposes, the Corps ceased to exist. (Senarmont commanded Auguereau's artillery). In the action of Heilsberg, 10 June, two divisions of Soult's Corps (Carra S. Cyr's and S. Hilaire's) during their advance exposed themselves to the surprise case-shot fire of a Russian battery and their losses were very heavy. It was these two recent examples of the rapid and paralysing effect from case-shot fire that Senarmont had pondered over and drawn the correct inference from.

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ciated the possibilities of field artillery, and well were his confidence and daring rewarded. By the way he performed his difficult task Senarmont furnished undeniable proof that he was a great general as well as a great gunner; bringing into action the full resources of his artillery reserve he overcame all difficulties. The numerical superiority of the Russian guns proved of no avail against Senarmont's superior leadership; their dispersed batteries were no match for his mass of guns, for in the Russian Artillery there was no unity of direction and no attempt was made to combine the fire of the dispersed batteries; and with comparatively small means Senarmont managed to accomplish a truly great end, a result that stands as an abiding testimony to his genius.

Senarmont's achievement with his 30 guns made clear to the military world that a new era had dawned for the Artillery Arm and from that time onward Field Artillery tactics became a subject for serious study.

The case shot attack at Friedland was a glorious triumph for the French Artillery and once more they were the pioneers in Artillery tactics, and Napoleon was quick to see how much was involved in this particular development. Henceforward the case-shot attack became a recognised feature of the Napoleonic battles; and when the action was ripe for the decisive stroke, the foe had staked his last reserve and his powers of endurance were slackening, then the Batteries of the Guard Artillery would dash to the front, just as Senarmont had done at Friedland, and unlimbering within case-shot range they proceeded to tear a breach in the opposing battle line which the Guard, Horse and Foot, would storm at the critical moment.[1] Is it too much to claim that here at Friedland in Senarmont's manœuvre we find the genesis of our modern artillery tactics? Both in the Napoleonic Armies and to-day we aim at the same combination of mechanical perfection in the technical skill of the arm with correct tactical employment of the batteries engaged, to achieve the one essential—the complete destruction of the objective which is of the greatest tactical importance at the moment; also we realise, as Senarmont did, that "the greater the difficulties of the infantry, the more fully should the fire power of the artillery be developed,"[2] for "the assault is made possible by superiority of fire,"[3] and now, as in 1807, the guns open the way for the infantry advance.

Senarmont does not deserve praise simply because he massed 30 guns, but because he seized the right moment to do so and then concentrated their fire on the right target. In his able and eager hand the Artillery succeeded where the Infantry had failed; and

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[1] Owing to the introduction of the rifle the "Case-Shot attack" has become impossible in the face of the unshaken fire-power of the defence armed with modern weapons. But to-day immediately before the Infantry assault, the more powerful modern artillery can converge an overwhelmingly destructive fire on the defence and beat down all resistance by a hurricane of projectiles; while machine guns and automatic rifles now supply that close co-operation of concentrated fire that is essential during the Infantry assault.

[2] F.S. Regns., Part I, Chap. VII, "The Battle."

[3] F.S. Regns., Part I, Chap. VII, "The Battle."

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closing up to the Russian Infantry[1] he placed an overwhelming barrage on the selected spot until all resistance had been broken down and the French Infantry were once more ready to attack, then the guns ceased firing[2] and the Infantry immediately delivered their assault, Senarmont following up with his guns to bring aid to them should they once more meet with opposition they could not overcome single-handed.

Never before Friedland had the massed batteries of a Corps manœuvred offensively to open a way, by their fire, through the opposing army. On June 14, 1807, the Artillery arm at last had taken its proper place in battle; at last it had become a separate arm, and as the years rolled on it was to become more and more important until it reached the almost dominating position that it holds to-day.

Primarily to Napoleon, *le génie incarné de la guerre*,[3] and to Senarmont these things are due; for they first realised its possibilities, they showed how it should be handled in an offensive action; and, so long as guns shall speak, imperishable Fame is theirs.

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[1] The short range of smooth-bore guns firing case-shot was the reason why the guns had to be advanced so close to their objective in order to get the necessary effect. In the Napoleonic era the fire of a long line of guns could not be concentrated on one target; and, except in our Army, shrapnel was then unknown.

That is the real reason why an Artillery Reserve was necessary in the Napoleonic times and it was never engaged until the decisive point had been made clear by the preliminary fighting, *on s'engage partout et puis l'on voit*. In this *combat d'usure* the enemy was held to his position all along the line and his reserve was fully engaged. To-day with the powerful modern weapons and propellants the old artillery tactics have been developed almost beyond recognition.

[2] To day, of course, the artillery lift at this stage. That procedure was hardly possible with case-shot.

[3] Clausewitz.

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APPENDIX A.

Battle of Friedland.

Grand Army.

Order of Battle.[1]

Imperial Headquarters.

Commander-in-Chief—His Majesty the Emperor Napoleon.
Lieut.-General Duroc, Grand Marshal of the Palace.
Lieut.-General Caulaincourt, Grand Master of the Horse.
General Aides-de-Camp. (7).—

Lieut.-General	Lemarois,	Major-General	Mouton,
,,	Savary,	,,	Bertrand,
,,	Rapp,	,,	Lebrun.
,,	Reille,		

Orderly Officers (14).
Chief of the Staff—Marshal Berthier, Prince of Neufchâtel, assisted by 80 other officers; whilst the General Staff in addition totalled 88 officers.

The following units of the Grand Army appear to have taken part in the Battle:—

Reserve Corps—		MARSHAL LANNES.
Divisions—	Oudinot	— 9 Bns. Grenadiers;
	Verdier	— 3 Regts. Infantry (2nd Light; 3rd and 72nd);
	Von Besser	— 1 Regt. Hussars; 2 Regts. Cuirassiers (Saxon).
	8 Corps	— MARSHAL MORTIER.
Divisions—	Dupas	— 5 Regts. Infantry (4th Light, 15th and 58th, and 2 others); 2 Regts. Dutch Cavalry.
	Dombrowsky	— 4 Regts. Infantry (Polish);
	Fresia	— 2 Regts. Polish Cavalry.
	6 Corps	— MARSHAL NEY.
Divisions—	Marchand	— 5 Regts. Infantry (6th Light; 39, 69, and 76, and 1 other);
	Bisson	— 5 Regts. Infantry (25th and 31st Light; 27, 50, 59);*
	Colbert	— 3 Regts. Cavalry, (3 H., and 10 and 15 Ch.);
	1 Corps	— MARSHAL VICTOR (after Bernadotte was wounded on 6 June).
Divisions—	Dupont	— 4 Regts. Infantry (9th Light; *24, 32, 96);

[1] *Histoire des Campagnes de L'Empereur Napoléon, 1805-1809*, p. 285 301.

* These 2 Regiments—9th Light and 59th of the Line—formed part of Desaix's Division in his great attack at the crisis of the Battle of Marengo, 14th June, 1800. The 9th Light Infantry(now represented by the 84th Infantry Regiment in the French Army) obtained from Napoleon the designation of "Incomparable," for its share in the glorious Marengo Campaign. In the Battle of Friedland it suffered a loss of 425 killed and wounded. (*Historiques des Corps de Troupe de l'Armée Française.*)

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Lapisse — 4 Regts. Infantry (16th Light; 8, 45, 54);
Villatte — 4 Regts. Infantry (27th Light; 63, 94, 95);
Beaumont — 3 Regts. Cavalry (2, 4, and 5Hussars).

Imperial Guard—MARSHAL BESSIERES.

1 Brigade, (4 Battalions), Grenadiers, (dismtd.);
1 Brigade, (4 Battalions), Chasseurs, (dismtd.);
2 Regts., Fusiliers, (4 Battalions);
1 Brigade, (6 Squadrons), Grenadiers, (Mounted);
1 Brigade, (6 Squadrons), Chasseurs, (Mounted);
1 Regt., *Gendarmerie d'élite*, (2 Squadrons);
Dragoons of the Guard (4 Battalions, 2 Squadrons).

Cavalry Reserve.

Divisions—Nansouty—2 Regts., Carabiniers—(1st and 2nd);
4 Regts., Cuirassiers—(2nd 3rd, 9th, and 12th);*
,, Latour
Maubourg—6 Regts., Dragoons—(1, 2, 4, 14, 20 and 26);
,, Grouchy—4 Regts., Dragoons—(3, 6, 10 and 11);
,, La Houssaye—4 Regts., Dragoons—(17, 18, 19 and 27).

Total 95 Battalions and 146 Squadrons, about 80,000 men and about 200 guns.

APPENDIX B.

Napoleon's Attack Orders at Friedland.

(Corr. 12756).

Bivouac behind Posthenen,
14 June, 1807.

Marshal Ney will form the Right Wing, from Posthenen as far as Sortlack, taking over General Oudinot's position.

Marshal Lannes will form the Centre; continuing the line on the left of Marshal Ney, from Heinrichsdorf to a point almost opposite Posthenen.

Oudinot's Grenadiers, now forming Marshal Lannes' right wing, will move slowly to the left so as to attract the enemy's attention to them.

Marshal Lannes will draw in his Divisions as much as possible, so as to have the chance of forming them into two lines.

Marshal Mortier will form the Left Wing, he will hold Heinrichsdorf, covering the Königsberg Road, and form up facing the Russian Right Wing.

Marshal Mortier will not advance at all, as the movement will be made by our Right Wing which will wheel round pivoting on our Left.

* The 12th is the cuirassier regiment shown by Meissonier in his picture "1807"; the regiment also figures in his picture "1805." The regiment was formed in 1668 under the name of *Le Dauphin*, the first commanding officer being the brother of Louise de la Vallière. The regiment has a most distinguished record. (*Historiques des Corps de Troupe de l'Armée Française*).

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General Espagne's Cavalry and General Grouchy's Dragoons, joining the Cavalry of the Left Wing, will manœuvre so as to do the greatest possible damage to the enemy, as soon as the vigorous attack of our Right Wing forces him to realise the necessity of retreating.

General Victor and the Imperial Guard, both mounted and dismounted, will act as the Reserve and will form up at Grünhof, Bothkein, and behind Posthenen.

La Houssaye's Division of Dragoons will take orders from General Victor: Latour Maubourg's Dragoons will be attached to Marshal Lannes and will co-operate with his corps Cavalry during the Battle.

I shall be with the Reserve.

The advance is to be made by the Right and the initiative will be left to Marshal Ney, who will wait for my orders before commencing.

At the moment when the Right advances all the guns along the whole line will redouble their fire in the most useful direction, so as to cover the attack made by the Right Wing.

NAPOLEON.

APPENDIX C.

Itinerary of the Emperor Napoleon during the Campaign.*

June 1 Danzig. Review of Lefebvre's Corps.
,, 2 Marienburg.
,, 3 Returned to Finkenstein at 7 p.m.
,, 6 (8 p.m.) Left Finkenstein and slept at Saalfeld.
,, 7 Slept at Ney's Head Quarters near Deppen.
,, 8 Arrived at Alt Reichau at noon.
,, 9 Leaving at 3 a.m. he was present at the fighting before Güttstadt, and halted there that night.
,, 10 Left at 6 a.m., marched to Heilsberg with the Army, commanded during the action and bivouacked on the Battlefield.
,, 11 Entered Heilsberg after Bennigsen withdrew.
,, 12 Moved to Eylau.
Sunday—
,, 14 Reached the Battlefield of Friedland about noon, took over the command, and bivouacked on the Battlefield after the action finished about 10 p.m.
,, 15[1] Near Wehlau.
,, 18 Gross Skaisgirren.
,, 19 Reached Tilsit at 2 p.m.

The above will give some idea of the Emperor's activity during a campaign. Headquarters did not always bivouac at the same place as Napoleon.

* From *Itinéraire Général de Napoléon* I (2nd edition) by A. Schuermans.
[1] After Friedland only the principal dates are shown.

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APPENDIX D.

Lieut. General Alexandre Antoine Hureau de Senarmont (1769-1810) was born at Strasburg, and he was educated at the Military College of Vendôme (1780) and afterwards at the Artillery College at Metz (1784). He obtained his first commission in the Artillery on 1 Sept. 1785, being appointed to the Régiment de Bésancon (artillerie).

He was promoted Colonel for his distinguished service in the Battle of Marengo, 14 June, 1800. He became a General Officer on 10 July 1806. He had been proposed for this well merited distinction in the previous year and the Emperor then said to him, "You are very young." "Sire", answered Senarmont, "I am your age."

Senarmont became a Baron of the Empire on 2 July 1808; and on 26 August 1808 he was appointed to command the Artillery of the I Corps (Victor) of the "Army of Spain." By December he had been promoted to Lieut.-General, again for his distinguished conduct in the field.

Senarmont was always frank and absolutely fearless when he considered it necessary to give advice, no matter to whom he spoke.

In 1809 he gave to King Joseph the celebrated warning: "Sire, "if you do not hang a marshal as an example to the rest, you will "be driven from Spain within six months." The King was not strong enough to act in the way suggested by the direct and resolute Senarmont, and his fate is now a matter of history.

Finally in Oct. 1810 at the age of 41, whilst employed in the Siege of Cadiz, General Senarmont was struck by an 8″ shell and died immediately.* Such was the end of a Gunner whose life and exploits are an honour to all Gunners for ever.

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* From the article on *Senarmont* in *Grands Artilleurs* by *M. Girod. de l'Ain*, pp. 155-239. For "Friedland" see particularly pp. 179-184, and Senarmont's report on the Battle to General Victor, pp. 224-226.

At Wagram (1809) Napoleon is said to have exclaimed "Would that I had Senarmont here." No praise could be more valuable than this involuntary remembrance.

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SOME NOTES ON POINTS AFFECTING STABILITY IN CARRIAGES OF THE 18pdr. TYPE.

By Captain W. A. Quennell, A.O.D., I.O.M.

THE HYDRAULIC BUFFER.

THE fullest discussion of the general features of hydraulic buffers known to me is contained in Rausenberger's Theory of the Recoil of Guns, which should be consulted by those who may wish to study the question exhaustively. The author enters into details which cannot be modified once the carriage has been constructed, and in the following notes I propose to deal only with those aspects of the question which may either affect the accuracy of the shooting, or lead to the destruction of some of the fittings. The most important point which comes under these heads and is at the same time within the control of Battery Officers is the correct filling of the Buffer and it is impossible to avoid dealing with some of the Theory of Recoil if a just appreciation of the vital importance of this point is to be formed.

Recoil then takes place in three stages.

In the first stage we have the powder pressure acting on the shot and urging it forward and on the gun urging it backward. The shot receives positive acceleration from the powder and a negative acceleration due to the resistance of the driving band to being engraved and forced through the rifling. The gun receives positive acceleration from the powder and a negative acceleration due to the driving band (and equal to the negative acceleration of the shot) but in addition it has a negative acceleration due to the resistance of the buffer, and the latter can be further sub-divided into the resistance of the springs, which is proportional to their compression, and the resistance offered by the liquid passing between the piston and the grooves of the buffer cylinder, and this last resistance is dependant on the velocity with which the gun is recoiling.

In the second stage the shot having just left the bore, the powder pressure does not instantaneously become zero, it takes time to die away and during this time acts as a positive acceleration on the gun, reduced only by the negative acceleration due to the buffer resistance.

This second stage of the recoil might be further subdivided, since obviously at some period after the shot leaves the muzzle and probably during the second stage the buffer resistance will equal the powder pressure, the nett acceleration will be zero and all subsequent nett acceleration negative.

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In the third and simplest stage of the recoil the velocity of the gun will be reduced to zero by the negative acceleration of the buffer, which is now the only force acting.

To ascertain the exact condition of the gun at each instant after firing requires a closer knowledge, than is readily available, of:—

(a). The pressure of the powder gases at any instant after firing or when the shot has passed over a certain length of the bore.

(b). The power required to engrave the driving band and force it through the bore.

(c). The time taken for the powder pressure to reach zero, and the law governing the variation in pressure after the shot has left the muzzle, i.e. does the pressure diminish uniformly or otherwise.

Without these data the exact velocity of the gun cannot be calculated with accuracy and therefore neither can the resistance of the liquid in the buffer. But close approximations can be made to the velocities at stated times, by equating the momentum acquired by the gun to that acquired by the shot (a) at the muzzle and (b) at the time the powder pressure reaches zero.

The equation expressing this is:—

where $GV = (s + ac)v$

G = weight of gun and recoiling bodies

V = velocity of recoil

s = weight of shot

c = weight of charge

v = Muzzle Velocity

a = a constant

To obtain the velocity of recoil at the moment the shot leaves the muzzle a is taken as ½, that is to say ½ the charge is considered to move forward with the shot and half backward with the gun.

The Text Book of Gunnery gives as the value of the constant a to be used for calculating the velocity of recoil as 2.

We shall in the following discussion neglect friction, assume that the centre of gravity of the recoiling bodies is on the axis line of the gun, and neglect the buffer resistance during the period of positive acceleration. So taking $G = 1050$ lbs., $s = 18{\cdot}5$ lbs., $v = 1590$ f/s, $c = 1{\cdot}5$ lbs., and $a = 2$ we find $V = 32{\cdot}5$ f/s.

We will also assume that the average velocity of the shot through the bore and of the gun in recoil is two-thirds of the maximum velocity in each case so:—Average velocity of shot = 1060 f/s and since the distance the shot travels through the bore of an 18-pr. gun is 82·3″ the time taken by the shot to travel through the bore is

$$\frac{82{\cdot}3}{12 \times 1060} = {\cdot}0065 \text{ seconds.}$$

Taking the average velocity of recoil as 21·67 f/s the space passed over in ·0065 seconds is:—

$$21{\cdot}67 \times 12 \times {\cdot}0065 = 1{\cdot}69''$$

So that after recoiling 1·69″ the gun has acquired a Velocity of 32·5 f/s. These figures are only approximate and are only sufficiently accurate for showing the difference between the results with a correct-

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ly and an incorrectly filled buffer. They are not sufficiently accurate to form the basis of a criticism of the 18-pr. buffer. The result so far is represented by the point M on the diagram.

The springs form the next and simplest part of the buffer to discuss. Elaborate calculations will be found in Rausenberger and many other Text-books by which the resistance of springs can be calculated from their dimensions and the Modulus of Elasticity of the material used but the latter information is not available, so for the present purpose the result of a test of a number of finished springs will probably be much more accurate. In the diagram the line JKL representing at each position of recoil and run-up the spring pressure, has been obtained by measuring a number of unloaded springs and the compression produced by a load of 56 lbs. and assuming that under different compressions, the pressures exerted are proportional to the compressions. The initial compression of the springs when assembled in the buffer and the final compressions at full recoil were obtained by measurement from a drawing, the corresponding pressure inserted in the diagram and the points J K and L obtained, joined by straight lines.

The resistance set up by the passage of the oil past the piston has now to be considered.

If the piston moves with velocity V for the small distance dx it displaces a Volume A dx, where A is the effective area of the piston. If A is measured in square feet and dx in feet the weight of the Volume A dx is 62·3 A dx s and its mass is $\frac{62{\cdot}3\ A\ dx\ s}{32{\cdot}2}$ where s is the specific gravity of the buffer oil.

This Mass is accelerated from O to v where v is the velocity of the oil passing through the apertures so that if a is the area of the apertures we have $a\ v = A\ V$ and assuming all measurements are in feet the Kinetic Energy of the oil passing through the apertures is:

$$\frac{62{\cdot}3\ A\ dx\ s\ (A\ V/a)^2}{64{\cdot}4}$$

But this Kinetic Energy imparted to the oil must be equal to the work done as the piston moves through the small distance dx, that is it must equal H dx where H is the average total pressure on the piston during the time it is passing through the space dx, hence:

$$H = \frac{62{\cdot}3\ A^3 s\ (V/a)^2}{64{\cdot}4}$$

A jet of liquid passing through an aperture does not occupy the full area of the aperture, so that the velocity of the jet would be greater than that indicated above, and there would also be a small frictional loss, so a combined correction c is inserted in the formula, also it is not convenient to measure small areas in square feet so if A which is cubed, and a which is squared are measured in square inches, but the velocity V in feet the formula becomes:

$$H = \frac{62{\cdot}3\ A^3 s\ (V/a)^2}{64{\cdot}4\ 144\ \ c}$$

The value of the coefficient c varies with the design of the buffer but for the purpose of this calculation will be taken as ·65

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Applying the formula to the 18-pr. we have the effective area of the piston during recoil equals the area of the piston minus that of the piston rod = ·7854 (4·84 − 1·96) = 2·262 square inches.

Taking the specific gravity of the oil at ·89 we get

$$H = \frac{62{\cdot}3\ 2{\cdot}262^3\ {\cdot}89\ (V/a)^2}{64{\cdot}4\ 144\ \ {\cdot}65}$$

$$= {\cdot}1065\ (V/a)^2$$

The area of the aperture varies during recoil and the depth of the groove is not given in the handbook but from an examination of the buffer drawing I think a fair approximation to the area of aperture at every position of recoil can be obtained from the expression:

$$a^2 = {\cdot}0199 - {\cdot}001246\ x^2$$

where a = area of aperture in square inches

x = recoil in feet.

The formula now becomes:—

$$H = \frac{{\cdot}0199 - {\cdot}001246\ x^2}{{\cdot}1065\ V^2} = \frac{V^2}{{\cdot}187 - {\cdot}0117\ x^2}$$

For the purposes of calculation the spring pressure can also be represented as a function of the recoil and if F is the spring pressure in lbs. we may write:

$$F = 500 + 200\ x$$

Now if the distance dx is taken so small that the spring pressure and the liquid pressure may be considered to be constant over the interval, the work absorbed by the buffer in the distance dx is $(H + F)\ dx$ and this must equal the Kinetic Energy lost by the gun, so that if V is the Velocity of the gun before and V′ that after passing through the space dx we have:

$$G\ (V^2 - V'^2)\ /2g = (H + F)\ dx$$

$$= \frac{V^2 dx}{{\cdot}187 - {\cdot}0117x^2} + (500 + 200x)\ dx$$

where G is again the recoiling weight and g = 32·2 f/s/s. We can now divide up the recoil into a number of small equal parts and assume that the Velocities, Spring pressures and Liquid pressures remain constant over each interval. For accuracy the intervals must be infinitesimal but for the purpose we have in view if we start from Velocity 32·5 f/s at 1·69″ = ·141 feet recoil and take the first interval to be ·059′ and succeeding intervals ·1′ the results will be sufficiently accurate to afford the comparison we are seeking.

The calculation by slide rule is given at Table A in the appendix and the results are represented by the portion of the diagram marked A.

The gun is now momentarily at rest, and since the volume of the oil in the buffer is obviously only sufficient to fill the cylinder when the gun is in the firing position and the piston rod home in the cylinder: when the piston rod is withdrawn during recoil, the volume of oil is no longer sufficient to fill the cylinder and there must be a partial vacuum behind the piston.

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The diameter of the piston rod is 1·4″ and its area 1·54 square inches and in a recoil of 48″ the volume of the piston rod withdrawn is 74 cubic inches.

The first stage of the run-up of the gun therefore is not resisted, the springs expand and transfer Kinetic Energy to the Gun and there is no resistance other than that due to friction until the oil behind the piston is sufficient to fill the space behind the piston.

The area of the piston which comes into action during the running forward of the gun is greater than that in action during recoil because it is not reduced by the area of the piston rod. We have the diameter of the piston = 2·2″ and its area 3·8 sq. ins., hence the vacuum will be absorbed and a liquid resistance will commence when the gun has run forward a distance of 74/3·8 = 19·5″ = 1·625′. Since the acceleration due to the springs does not vary with the velocity we need calculate the latter only at sufficient points to enable a curve to be drawn.

If F is the spring pressure at full recoil and F′ the spring pressure at say x' (measured from zero of recoil) then the energy lost by the springs is $\frac{F + F'}{2}(4 - x')$ and this must equal the Kinetic Energy acquired by the gun $= G V^2 / 2g = 16{\cdot}3 V^2$.

The calculation is given at Table B of the Appendix and the results are represented graphically by the portion marked B of the diagram.

In the second stage of the run-up the gun continues to receive energy from the springs, but the oil behind the piston now has to be forced through the cylinder grooves and so we have one positive acceleration due to the springs and one negative acceleration due to the liquid resistance.

The positive acceleration is again $500 + 200\,x$ and the negative acceleration is obtainable from the same expression as before i.e.

$$H = \frac{62{\cdot}3}{64{\cdot}4}\,\frac{A^3}{c}\,s\,\frac{V^2}{a^2}$$

but now A is as already explained the full area of the piston 3·8 square inches instead of 2·262 sq. ins.

As we are taking x as measured from the zero of recoil the same expression for the area of apertures is applicable for run-up as was used for recoil, i.e.

$$a^2 = {\cdot}0199 - {\cdot}001246\,x^2$$

and our formula for H becomes:

$$H = \frac{62{\cdot}3}{64{\cdot}4}\,\frac{3{\cdot}8^3}{1{\cdot}44}\,\frac{{\cdot}89}{{\cdot}65}\,\frac{V^2}{{\cdot}0199 - {\cdot}001246x^2}$$

$$= \frac{V^2}{{\cdot}0395 - {\cdot}00247x^2}$$

We can now form a new energy equation for this stage of the run-up:

$$\frac{G\,(V^2 - V'^2)}{2g} = \frac{V^2 dx}{{\cdot}0395 - {\cdot}00247x^2} - (500 + 200\,x)dx$$

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which states that the reduction of the Kinetic Energy of the gun in running forward the small distance dx is equal to the work done in overcoming the liquid resistance minus the work done by the springs.

Table C in the appendix shows the calculation of this part of the run-up and the results are graphically represented by the portion of the diagram marked C.

At 1·5′ measured from the zero of recoil the piston reaches the control plunger and additional resistance is introduced so that the formula for the liquid resistance needs extension.

Considering again a small movement dx, a certain volume of oil depending on the area of the control plunger is forced over its flats acquiring velocity and Kinetic Energy and by equating this Kinetic Energy to the product of the space dx into the liquid pressure we can calculate the latter with the same corrections applied as before. Now the oil forced out of the control plunger chamber passes first behind the piston, mixes with the oil already there and is ultimately forced through the cylinder grooves and it seems to me that the volume of oil forced through the grooves, while the piston passes through the space dx must be the same after the control plunger comes into operation as it was before, but the pressures set up behind the piston must be smaller, owing to the presence of the control plunger, because the combined pressure is greater and the velocities smaller. We can therefore keep the same expression for the liquid pressure behind the piston, but must now add a similar one for the pressure in the control plunger chamber.

The area of the control plunger is ·7854 sq. ins. and we will use as an approximation to the area of the apertures provided by the flats on the plunger,

$$\text{area} = \cdot 007 + \cdot 02x$$

Proceeding as before we get for the pressure in the Control plunger chamber the expression:

$$H2 = \frac{V^2}{\cdot 011 + \cdot 063x + \cdot 09\,x^2}$$

Calling $\cdot 0395 - \cdot 00247x^2 = L$ and $\cdot 011 + \cdot 063x + \cdot 09x^2 = M$ and as $G/2g = 16\cdot 3$ we now get for the energy equation:—

$$16\cdot 3\,(V^2 - V'^2) = V^2dx/L + V^2dx/M - (500 + 200x)\,dx$$

The results of the calculation are shown in Table D of the appendix and represented by the portion of the diagram marked D.

Calculation for a Buffer not Completely Filled.

We will assume a deficiency of 40 cubic inches of oil, then as the effective area of the piston is 2·262 sq. ins. the gun can recoil $40/2\cdot 262 = 17\cdot 68'' = 1\cdot 473$ feet before the liquid can offer effective resistance, and the only check to the recoil is that due to the spring pressure. Between ·141′ and 1·473′ there is no liquid pressure and the velocities can be calculated as shown at Table E of the appendix, the results are shown graphically by the portion E of the diagram.

For the remainder of the recoil we can calculate as in Table A but from the initial conditions that at 1·473′ recoil the velocity is 31·6 f/s.

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The results are given in Table F of the appendix and represented graphically by the portion marked F of the diagram.

During the recoil we have again the volume of the piston rod drawn out = 74 cubic inches, but to this we now have to add the volume of the oil deficient from the buffer (40 cubic ins.) so the Total Volume which must be swept out by the piston during run-up before the liquid offers resistance is 114 cubic inches and as the area of the piston is 3·8 sq. ins. the distance which must be run-up is 30″ = 2·5′ so that only 1·5′ of the run-up remains in which to check the velocity. Hence the control plunger will just commence to check the run-up at the same time as the liquid behind the piston begins to offer resistance by its passage over the piston. Stage 2 of the run-up will be missing, this shortens the calculation and is the reason why this particular shortage of oil was assumed.

We can now calculate the run-up with the results shown on Tables G and H of the appendix and represented graphically by the portions of the diagram marked G and H.

Stability of the Carriage.

Before the introduction of long recoil guns the buffer when provided, absorbed a small portion only of the recoil energy, and the whole gun and carriage recoiled several feet on the wheels, and had to be run up to the firing position again by hand, and of course relaid for line and elevation. This is not necessary with carriages which permit guns to recoil a sufficient distance to so reduce the buffer resistance that the latter is not sufficient to produce more than slight disturbance of the carriage on its wheels. With such carriages the gun detachments have been relieved of much arduous work.

The purpose of the increased length of recoil is not primarily to reduce the strains to which the carriage is subjected on firing, but by reducing those strains to increase the rapidity and accuracy of fire.

The increased steadiness permits the gunlayer to be seated on the carriage, and his duty is to keep the telescope pointer on the target or aiming point, or to bring a bubble into the centre of its run and it will obviously be easier for him to do this the steadier the carriage can be made during recoil and run-up and the standard aimed at is that at no portion of the recoil shall the wheels lift from the ground and at no part of the run-up shall the trail lift from the ground.

The handbook of the gun gives the weight of the carriage with gun as 25 cwt. 21 lbs. = 2821 lbs. and the pressure of the trail on the ground as 120 lbs., hence the pressure of the wheels on the ground (with the gun in the firing position) is 2700 lbs.

The length from the point of the trail to the line joining the wheel contact is 91·5″ and the moment of the weight on the wheels about the trail point is:

$$2700 \text{ by } 91{\cdot}5 = 246700 \text{ ″ lbs.}$$

The buffer pressure during recoil tends to lift the wheels and will do so if its moment about the point of the trail exceeds the above. It is proved in the Text Book of Gunnery that the buffer pressure

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acts as if it were concentrated at the Centre of Gravity of the Gun and as the height of the gun axis is 36·86″ (with gun horizontal) the buffer pressure with gun in firing position must not exceed

246700/36·86 = 6700 lbs.

As the gun recoils the weight on the wheels is reduced in proportion to the recoil, and the buffer pressure must not rise above the permissible figure at any point of the recoil. The recoiling weight has been taken as 1050 lbs. and for a 48″ recoil, the reduction in the moment of the weight on the wheels about the trail point is 1050 by 48 = 50400 so the reduced moment is 196300 ″ lbs. and at 4′ recoil the buffer pressure must not exceed 196300/36; 86 = 5330 lbs. These two figures (6700 at 0 recoil and 5330 at 4′ recoil) are represented by the points Y and Z on the diagram, and if at any point of the recoil the combined spring and liquid pressure rises above the straight line YZ, the wheels will lift from the ground.

Similarly during run-up we have, when the gun reaches the firing position, the moment of the trail pressure about the line of wheel contact = 120 by 91·5 = 11000″lbs. dividing this by 36·86 we see that the nett buffer pressure must not exceed 298 lbs.

As the gun recoils the weight on the trail is increased in proportion to the recoil, and the moment of the trail pressure about the line of wheel contact is increased by 50400 ″ lbs. (1050 by 48) making a total Moment of 61400 ″ lbs., dividing 36·86 we see that at the commencement of run-up the buffer pressure must not exceed 1665 lbs.

These two results (1665 at 4′ and 298 at 0) are represented by the points Y′ and Z′ on the diagram and if perfect stability is to be secured the curve representing the nett buffer pressure at any point of the run-up must not rise above the straight line Y′Z′.

Indicator Diagrams.

In drawing the diagram the velocity of recoil is given by the curve O M 4 which is drawn above the base line, so, as the velocity of run-up is of course in the reverse direction the curve which represents it (4 N P) is drawn below the base line. In order that the parts of the diagram obtained from each table should be easily recognisable the portions of the diagram referring to the run-up have been reversed i.e. as the recoil is represented as from left to right the run-up should be shown as from right to left, so that it would be drawn directly under the recoil portions, instead of to the right which is I think slightly more clear.

The spring pressures are represented as the ordinate of the lines J K L and as the direction of the spring pressure does not change as the motion of the gun reverses, the lines J K L are drawn everywhere above the base line.

The liquid pressures are represented during recoil by the vertical intercepts between the line J K and the curve JQRK and during run-up by the intercepts between the line KL and the curve STUV, except for the pressures due to the control plunger, which are represented by the vertical intercepts between the two curves UV & WX.

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Slight modification to the lettering on the diagram is required for the partially filled buffer but this will be obvious from inspection.

It will be seen that on both recoil and run-up the total or nett buffer pressure is given by the vertical ordinates of the curves OJQRK4 and TUWXO (measured from the base line) for on recoil where the spring and liquid pressure both check the motion, this ordinate represents their sum, but on run-up where liquid pressure opposes spring pressure the ordinate represents their difference.

In making these calculations a formidable list of assumptions and approximations has been made and the work has been done at odd times and places so there are probably a good many errors, and the results are not considered to be sufficiently accurate on which to base a criticism of the 18-pr. buffer, but they are quite good enough to illustrate the effect of insufficiency of oil in buffers of the 18-pr. type.

With a correctly filled buffer it will be seen that the nett buffer pressure rises above the stability limit twice during the run-up, and I think the first occasion (at the peak T) is probably fairly near the truth because the oil must come into action rather abruptly after the vacuum due to the withdrawal of the piston rod has been overcome. The second occasion (X) at the end of the run-up can probably be dismissed because we have omitted to consider the effects of friction, which probably absorbs sufficient energy during the run-up to ensure that at the end the velocity has been so reduced that the resulting liquid pressure should be within stability limits. It should also be remembered that for simplicity the calculation has been made for zero elevation. At the average elevations used the velocity of run-up and the resulting liquid pressure would both be less.

With the partially filled buffer it will be seen that the velocities both of recoil and run-up are greater than with a full buffer and that the resulting liquid pressures bring the total buffer pressures above the stability limits during the whole period of recoil and run-up that the liquid is in action the wheels will therefore lift during recoil and the trail will lift during the run-up, and it will take the gunlayer longer to bring the telescope back on to the target or aiming point, or the spirit bubble to the centre of its run, and the detachment will have the unnecessary fatigue of relaying for every round. There will be a certain loss of speed or accuracy and a possible loss of both.

During recoil the gross liquid pressure falls towards the end of the recoil, but with the partially filled buffer there is an abrupt rise of pressure at the end. The method of calculation adopted is a little too crude really for the accurate determination of pressures in this part of the recoil where they are rising so rapidly but we can be quite sure there is a sudden rise and the magnitude of the maximum liquid pressure may I think be taken as in the neighbourhood of 10000 lbs., whereas with the correctly filled buffer the maximum liquid pressure was 5660 lbs., and since the effective area of the piston during recoil is 2·262 sq. ins. we have for the maximum liquid pressures per square inch:—

With buffer correctly filled 2500 lbs.

With buffer lacking 40 cu. ins. of oil 4420 lbs.

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This is a very appreciable rise and since the shortage of oil was due in the first place to defective packing probably: the increased pressure will accentuate the loss, on every succeeding round there will be less oil in the buffer and the pressures will rise in geometrical progression, forcing out more and more oil, until about 111 cubic inches of oil or about 3 pints have been lost then there will not be sufficient oil in the buffer to afford any liquid resistance at all, the recoil will be checked by the springs only and since the Kinetic Energy of the recoiling gun is about 17200 ′ lbs. and the energy absorbed by the springs in 49″ is about 3670 ′ lbs., the difference of 13530 ′ lbs. must be absorbed by lifting the carriage, but the power necessary to do this is communicated through the piston rod, cylinder, inner springs, inner spring case and outer springs and damage of these fittings is certain. The result would be the putting out of action of the gun. That this is no fanciful picture is shown by a Report I have seen of a carriage received for repair in which the piston rod was found to have stretched nearly an inch, and I have myself had to condemn a number of spring cases which had stretched appreciably.

In my opinion it is impossible to emphasise too much the necessity of keeping the buffer correctly filled:—

(a). To avoid damage to parts of the buffer.

(b). To maintain accuracy and speed of firing.

It is difficult to say which of the two is the more important while close shooting over our own troops is a matter of daily occurrence.

It is probable that the "Jump" of the carriage is also affected by lack of oil in the buffer, this would also affect the accuracy of shooting by introducing a slight alteration in the shot's angle of departure; any such alteration would affect the results of registration and calibration which are almost certain to have been carried out with a correctly filled buffer. To ascertain whether there is some effect on the "Jump" produced by lack of oil would require the experiment indicated at Page 90 Text Book of Gunnery Part I. and this cannot well be carried out locally, it is therefore imperative that the buffer shall always be in the same condition when the gun is fired, the necessary condition is that it shall be Correctly Filled.

The Carriage.

The Carriage is described fully in the Handbook.

Repair of some of the parts is difficult on sound mechanical lines, because the weight has been reduced to a minimum, so care should be taken to subject the carriage to no unnecessary strains, so

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avoiding excessive wear and the replacement which may be the only remedy.

With the exception of the buffer, the carriage receives greater strains when travelling, than when firing. Clamps should always be used for travelling as they relieve the gears of a great deal of strain and wear. The effect of worn gears may again be an alteration in "Jump" the undesirability of which is indicated in the preceding section.

No. 1 Dial Sight.

Complaints are often made of play in these dial sight stems. It may be pointed out that as the mean radius of the feather from the centre line of the stem is only about ·625″ (corresponding to a circumference of 3·927″) therefore the arc at the feather which corresponds to one degree is only ·011″. So if there is a little over one hundredth of an inch play between the feather on the stem and the featherway in the socket, or if there is the same play between the stem and the socket itself, an inaccuracy in the readings of horizontal angles of 1 degree will be possible. This will give some idea of the accuracy of fit necessary to be maintained.

There are other points which affect the accuracy of the No. 1 Dial Sight, thus if the hole through the stem for the split pin is slightly low, on inserting the pin the feather on the stem is raised slightly out of the feather way and play permitted.

The fit of the central hole through the sight arm where it is attached to the Dial Plate is another possible source of error.

The "Fit" of the Dial Sights should be got as good as possible by repair or replacement and once the condition of all dial sights has been made as satisfactory as possible they should be marked to the guns to which they have been fitted and always used with the same gun.

Director Stands.

Error will be possible in the readings of horizontal angles if the joint between the legs and the baseplate is allowed to become slack. The joint should be kept tight enough just to support the leg against its own weight. The error introduced by slackness of joints is directly proportional to the length of leg in use. So with the No. 1 Director Stand for example men should be instructed not to set up the stand with the lower half of the leg unless absolutely necessary to secure a full field of view. Risk of exposure to the men using the Director would thereby be reduced.

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APPENDIX.

Table A.

Calculation of the Equation :—

$$G(V^2 - V'^2)/2g = \frac{V^2 dx}{\cdot 187 - \cdot 0117x^2} + (500 + 200x)dx$$

Recoil	$1.87 - .117x^2$	V^2	H	F	$(H+F)dx$	$V^2 - V'^2$	V
.141	1.868	1055	5660	528	365	21.8	32.5
.2	1.865	1033	5550	540	609	37.3	32.2
.3	1.86	996	5360	560	592	36.1	31.6
.4	1.85	960	5200	580	578	35.5	31.0
.5	1.84	925	5025	600	562	34.5	30.4
.6	1.83	891	4870	620	549	33.6	29.8
.7	1.82	857	4710	640	535	32.8	29.3
.8	1.80	824	4570	660	523	32.1	28.7
.9	1.78	792	4450	680	513	31.4	28.2
1.0	1.76	761	4330	700	503	30.8	27.6
1.1	1.73	730	4220	720	494	30.3	27.0
1.2	1.70	700	4120	740	486	29.8	26.4
1.3	1.67	670	4010	760	477	29.2	25.9
1.4	1.64	641	3910	780	469	28.7	25.4
1.5	1.61	612	3800	800	460	28.2	24.8
1.6	1.57	584	3720	820	454	27.8	24.2
1.7	1.53	556	3630	840	447	27.4	23.6
1.8	1.49	529	3550	860	441	27.0	23.0
1.9	1.45	502	3460	880	434	26.6	22.4
2.0	1.40	475	3390	900	429	26.3	21.8
2.1	1.35	449	3330	920	425	26.0	21.2
2.2	1.30	423	3250	940	419	25.7	20.6
2.3	1.25	397	3170	960	413	25.4	20.0
2.4	1.20	372	3100	980	408	25.0	19.3
2.5	1.14	347	3040	1000	404	24.8	18.6
2.6	1.08	322	2980	1020	400	24.5	18.0
2.7	1.02	297	2910	1040	395	24.2	17.25
2.8	.96	273	2840	1060	390	23.9	16.56
2.9	.89	249	2800	1080	388	23.8	15.8
3.0	.82	225	2750	1100	385	23.6	15.0
3.1	.75	201	2680	1120	380	23.3	14.2
3.2	.68	178	2620	1140	376	23.0	13.4
3.3	.60	155	2580	1160	374	23.0	12.5
3.4	.52	132	2540	1180	372	22.8	11.5
3.5	.44	109	2480	1200	368	22.6	10.5
3.6	.36	86	2380	1220	360	22.1	9.3
3.7	.27	64	2370	1240	361	22.2	8.0
3.8	.18	42	2330	1260	359	22.0	6.5
3.9	.09	20	2220	1280	350	21.4	4.47
4.0	0	0		1300			0

Table B.

Calculation of the Equation $16{\cdot}3\ V^2 = \frac{F + F'}{2}(4 - x')$

X	F	$\frac{F+F'}{2}$	$16.3\ V^2$	V^2	V
4.0	1300				
3.9	1280	1290	129	7.92	2.82
3.7	1240	1270	381	23.4	4.83
3.3	1160	1230	862	52.8	7.26
2.5	1000	1150	1725	105.8	10.3
2.375	975	1138	1847	113.3	10.66

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Table C.

Calculation of the Equation :—

$$16{\cdot}3\,(V^2 - V'^2) = \frac{V^2 dx}{{\cdot}0395 - {\cdot}00247\,x^2} - (500 + 200x)dx$$

X	.0305 − .00247x^2	V^2	H	F	H − F	$V^2 - V'^2$	V
2.375	.0256	113.3	4360	975	3385	15.6	10.66
2.3	.0265	97.7	3680	960	2720	16.7	9.9
2.2	.0276	81	2930	940	1990	12.2	9
2.1	.0286	68.8	2400	920	1480	9.1	8.29
2.0	.0296	59.7	2020	900	1120	6.9	7.72
1.9	.0306	52.8	1725	880	845	5.2	7.26
1.8	.0315	47.6	1510	860	650	4.0	6.9
1.7	.0324	43.6	1345	840	505	3.1	6.6
1.6	.0332	40.5	1220	820	400	2.4	6.36
1.5	.0339	38.1	1125	800	325	2.0	6.17

Table D.

Calculation of the Equation :—

$$16{\cdot}3\,(V^2 - V'^2) = V^2 dx/L + V^2 dx/M - (500 + 200x)dx$$

where $L = {\cdot}0395 - {\cdot}00247\,x^2$ and $M = {\cdot}011 + {\cdot}063x + {\cdot}09x^2$

X	L	M	V^2	H1	H2	F	Nett	$V^2 - V'^2$	V
1.5	.0339	.308	38.1	1125	124	800	449	2.8	6.17
1.4	.0347	.275	35.3	1020	128	780	368	2.3	5.95
1.3	.0353	.245	33.0	935	135	760	310	1.9	5.75
1.2	.0359	.217	31.1	867	143	740	270	1.7	5.58
1.1	.0365	.189	29.4	805	155	720	240	1.5	5.42
1.0	.0370	.164	27.9	755	170	700	225	1.4	5.28
.9	.0375	.141	26.5	707	188	680	215	1.3	5.15
.8	.0379	.119	25.2	665	212	660	217	1.3	5.01
.7	.0383	.099	23.9	625	242	640	227	1.4	4.89
.6	.0386	.081	22.5	584	278	620	242	1.5	4.74
.5	.0389	.065	21.0	540	323	600	263	1.6	4.58
.4	.0391	.050	19.4	492	388	580	300	1.8	4.4
.3	.0393	.038	17.6	448	463	560	351	2.2	4.2
.2	.0394	.028	15 4	391	550	540	401	2.5	3.92
.1	.0395	.018	12.9	326	717	520	523	3.2	3.59
0	.0395	.011	9.7	245	881	500	626		3.11

Table E.

Calculation of the Equation :—

$$16{\cdot}3\,(V^2 - V'^2) = \frac{F + F'}{2}\,(x - {\cdot}141)$$

X	F	$\frac{F+F'}{2}$	16.3 $(V^2 - V'^2$	$V^2 - V'^2$	V^2	V
.141	528.2				1055	32.5
.641	628.2	578.2	289.1	17.73	1037.3	32.2
1.141	728.2	628.2	628.2	38.5	1016.5	31.8
1.473	794.6	661.4	881	54.1	1000.9	31.6

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Table F.

Calculation of the Equation:—

$$\frac{G(V^2 - V'^2)}{2g} = \frac{V^2 dx}{\cdot 187 - \cdot 0117x^2} + (500 + 200\,x)dx$$

which is the Equation of Table A but now the initial conditions are Velocity 31·6 f/s at 1·473′ recoil vide table E, instead of 32·5 f/s at ·141′ recoil

Recoil	$1.87 - .117x^2$	V^2	H	F	$(H+F)dx$	$V^2 - V'^2$	V
1.473	1.62	1000.9	6280	795	214.4	13.15	31.6
1.5	1.61	987.8	6130	800	693	42.5	31.4
1.6	1.57	945.3	6020	820	684	42	30.8
1.7	1.53	903.3	5900	840	674	41.3	30.1
1.8	1.49	862	5780	860	664	40.7	29.4
1.9	1.45	821.3	5660	880	654	40.1	28.6
2.0	1.40	781.2	5580	900	648	39.8	28.0
2.1	1.35	741.4	5500	920	642	39.3	27.2
2.2	1.30	702.1	5400	940	634	38.9	26.5
2.3	1.25	663.2	5300	960	626	38.4	25.8
2.4	1.20	624.8	5200	980	618	37.9	25.0
2.5	1.14	586.9	5150	1000	615	37.7	24.2
2.6	1.08	549.2	5080	1020	610	37.4	23.4
2.7	1.02	511.8	5010	1040	605	37.1	22.6
2.8	.96	474.7	4940	1060	600	36.8	21.8
2.9	.89	437.9	4920	1080	600	36.8	20.9
3.0	82	401.1	4900	1100	600	36.8	20.0
3.1	.75	364.3	4870	1120	599	36.7	19.1
3.2	.68	327.6	4820	1140	596	36.6	18.1
3.3	.60	291	4850	1160	601	36.9	17.1
3.4	.52	254.1	4900	1180	608	37.2	15.9
3.5	.44	216.9	4930	1200	613	37.6	14.7
3.6	.36	179.3	4990	1220	621	38.1	13.4
3.7	.27	141.2	5230	1240	647	39.7	11.9
3.8	.18	101.5	5650	1260	691	42.4	10.1
3.9	.09	59.1	6570	1280	785	48.2	7.7

The pressure is now rising so rapidly that to give accurate results very much shorter intervals would have to be taken, but we can approximate to the maximum pressure thus: It will be seen that our formula does not permit a greater recoil than 4′ because ·117 multipled by 4 squared = 1·87 and hence there is no opening for the liquid after 4′ recoil. Actually in an 18-pr. buffer the metal to metal recoil is 49 inches, but a formula giving 4′ recoil is simpler both for calculation and diagrammatic representation. So we have the velocity squared at 3·9′ = 59·1 and the Kinetic Energy remaining in the Gun = 59·1 by 16·3 = 964 of this in the last interval the springs absorb 129 and hence the liquid must absorb 835 and the average liquid pressure must be 8350 lbs. the pressure at 3·9 is 6570 lbs. hence assuming uniform rise of pressure that at 4′ recoil would be 10130 lbs.

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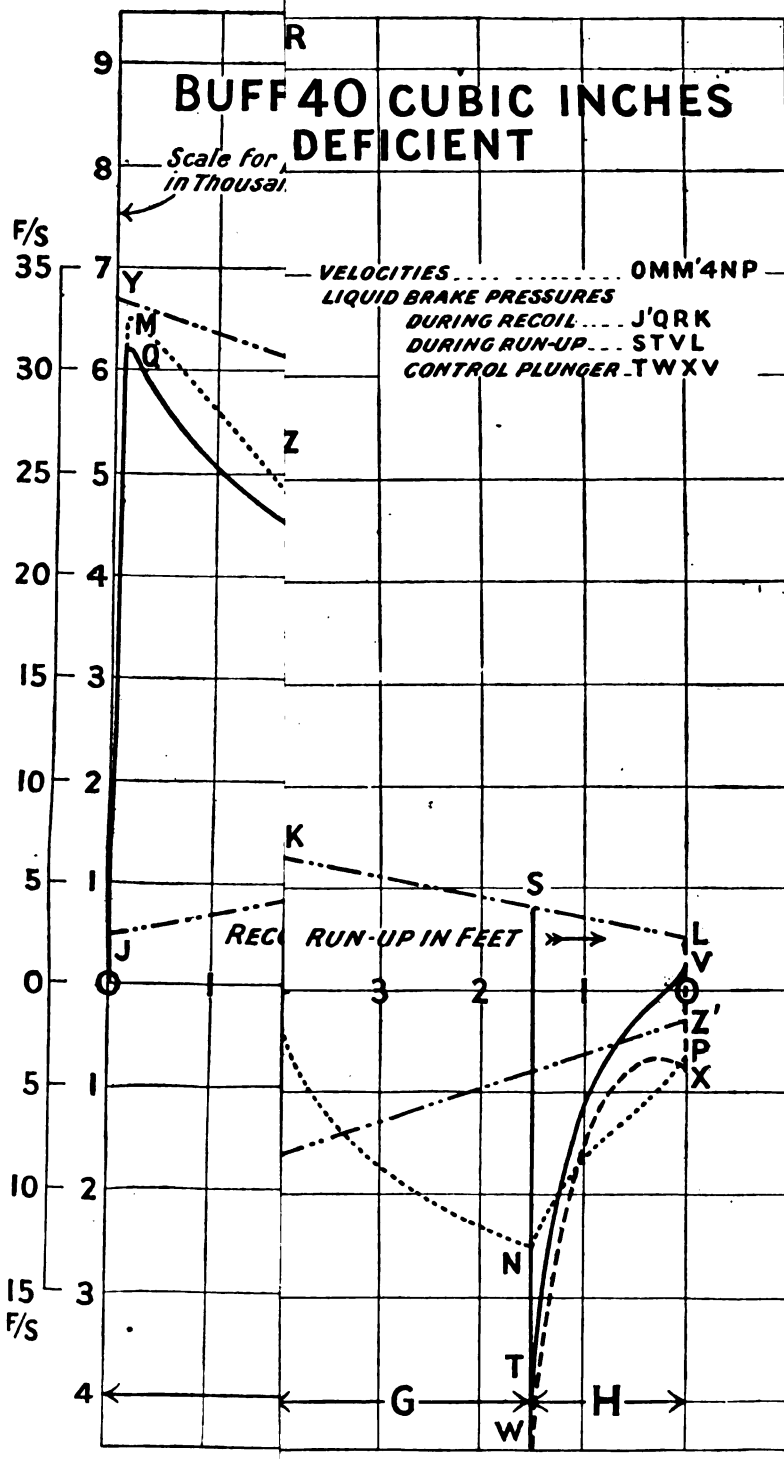

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Table G.

Calculation of the Equation:—

$$16{\cdot}3\ V^2 = \frac{F + F'}{2}(4 - x)$$

X	F	$\frac{F+F'}{2}$	$16.3V^2$	V^2	V
4.0	1300				
3.8	1260	1280	256	15.7	3.96
3.6	1220	1260	504	30.9	5.56
3.2	1140	1220	976	59.9	7.74
2.4	980	1140	1825	112	10.6
1.5	800	1050	2625	161	12.7

Table H.

Calculation of the Equation:—

$16{\cdot}3\,(V^2 - V'^2) = V^2dx/L + V^2dx/M - (500 + 200\,x)dx$
which is the same Equation as was used for calculating Table D and L and M stand for the same expressions as were used in Table D but the initial velocity now is 12·7 f/s instead of 6·17 f/s.

X′	L	M	V^2	H1	H2	F	Nett	$V^2-V'^2$	V
1.5	.0339	.308	161	4750	523	800	4473	27.4	12.7
1.4	.0347	.275	133.6	3850	486	780	3556	21.8	11.6
1.3	.0353	.245	111.8	3165	453	760	2858	17.5	10.6
1.2	.0359	.217	94.3	2620	434	740	2314	14.2	9.7
1.1	.0365	.189	80.1	2190	424	720	1894	11.6	8.96
1.0	.0370	.164	68.5	1850	417	700	1567	9.6	8.3
.9	.0375	.141	58.9	1570	417	680	1307	8.02	7.67
.8	.0379	.119	50.9	1340	427	660	1167	7.17	7.14
.7	.0383	.099	43.7	1140	442	640	942	5.77	6.6
.6	.0386	.081	37.9	982	468	620	830	5.09	6.15
.5	.0389	.065	32.81	844	506	600	750	4.6	5.73
.4	.0391	.050	28.21	723	564	580	707	4.33	5.32
.3	.0393	.038	23.88	609	630	560	679	4.16	4.88
.2	.0394	.028	19.72	501	705	540	666	4.08	4.44
.1	.0395	.018	15.64	396	870	520	746	4.57	3.96
0	.0395	.011	11.07	280	1006	500	786	4.82	3.32

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PACK ARTILLERY IN BUSH WARFARE.

By Captain D. D. Haskard, M.C., R.A.

THE campaign in British East Africa has provided much valuable experience in fighting and manœuvring artillery in the dense African Bush.

This, perhaps, was more so in the case of our Mountain Artillery, which was able to penetrate any forest or climb any mountain encountered during the advance and was at all times a part of the more mobile columns.

The conditions experienced were very different to those met with on the N.W. Frontier of India which has for some time past been the principal training ground for our Mountain Artillery.

The tactical difficulties were due to the density of the Bush and the Forests through which the enemy retreated, and where, he rightly chose to resist our advance. By so doing they greatly reduced the effectiveness of our superiority in all arms, especially in artillery.

Owing to the low visibility in the thick bush and difficulty in establishing communications, the artillery was greatly handicapped. The existing tracks were so bad that the heavier natures of ordnance were often unable to come up in time to take part in the action.

The lessons learnt were mostly in the Advance of 1916, which was almost continuous. The Mountain Artillery Units were allotted to various columns and met with varied experiences, each of them traversing districts which differed in their nature.

In addition to this, considerable difficulties arose in the prevention of the numerous diseases both to men and animals which caused such devastation, especially in the irregular corps.

In discussing this subject there is a distinct advantage in that the German Askari troops seemed to resort to a rather stereotyped form of tactics which consisted, essentially, in fighting in the bush, trusting to the invisibility of exceedingly well situated trenches and machine guns manned by Europeans and arranged so as to bring cross and covering fire on the attackers.

The inability on our part to properly locate the enemy's position, until committed to the attack, was one of our greatest handicaps. It was unfortunate that the R.F.C. were unable to assist the artillery on these occasions by spotting or taking photographs of the enemy positions beforehand as is done on the European Front.

When given time the enemy's fire positions were made almost impregnably strong, chosen as they were in the thick bush and still more often in high forest, where it was very difficult to bring effective

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artillery fire on to these positions to assist the attacking infantry. This was due to the inability on the part of our guns to "clear" the trees at "the target end" without endangering our own infantry, which in this thick country was able to draw very close to the enemy's fire trenches.

Opportunities were offered to the enemy to strongly entrench these positions across our only good line of advance when our columns had to halt and wait for the repair of railways, bridges and roads, to enable supplies to reach them.

The enemy had to be manœuvred out of these positions by wide turning movements carried out by very mobile and lightly equipped columns.

In the course of these wide turning movements it was almost the invariable rule that our troops would have to encounter strong rear-guards in a naturally strong position, but with only hastily prepared defences, left by the enemy to cover his evacuation.

In such actions we were invariably successful, though sometimes after some delay, during which the enemy succeeded in achieving the object of their rearguard action.

It is this latter form of attack which will be taken to exemplify the points relating to the artillery as it occurred repeatedly and will be treated under the heading of Battery tactics, followed by a few notes on Transport and Prevention of disease.

I. Battery tactics.
II. Transport.
III. Prevention of Diseases.

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1. Battery Tactics.

The various stages in an attack were roughly as follows:

1. Information of the presence of the enemy by a column on the march or contact with their advanced posts.
2. Dispositions and Deployment for the attack.
3. The advance for the attack.
4. The Fire Action.
5. The Breaking off of the Fight.

1. The advance guard of a column would receive information of the presence of the enemy from natives or by coming in contact with the enemy's picket line. It was found of considerable advantage when there was a prospect of an advancing column meeting the enemy, to use an Artillery Reconnaissance Officer with the Advance Guard Commander (as in F.A.T.). First hand information, which especially affected the Artillery, was then to be obtained first hand, and the nature of the ground observed. This officer was accompanied by a staff consisting of:—

Trumpeter or Horseholder, mounted.
One range taker, with a one man range finder.
One Telephonist with instrument.
One Reeler and 3 drums of wire (1 ½ miles).

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He was then in a position to inform his O.C. as quickly as possible and independently of the telephone.

(a). Whether the occasion justified the support of the artillery.

(b). Where the battery was likely to come into action, and this implied whether the battery should advance, halt or retire.

As a rule he was only able to express an opinion whether the support of the artillery was necessary or not, when the advanced guard troops had come into contact with the enemy's main position, and he remained with the advanced guard until he had done so. He then proceeded to look out for an Observation Post for the F.O.O., and if he had to do the F.O.O. himself he communicated with his O.C. with reference to the laying out of the telephone. In the event of its being required he gave the necessary orders for its being laid out. Having obtained all the information available he invariably reported to his O.C.

2. Dispositions and Deployment for the Attack.

On the O.C. Column making his dispositions for the attack it was the practice to send forward a F.O.O. who advanced with the infantry firing line and established his observation station with or near them. Whether the battery commander employed his artillery reconnaissance officer or not was a matter for him to decide. In deciding, the following points had to be considered:

(a). An officer who had not been ahead and viewed the situation and the character of the ground, was naturally greatly handicapped.

(b). The telephone would not have been laid out in the case of a fresh officer being employed, which would result in an additional delay and the infantry making their advance without the support of the artillery.

The increased difficulty of laying out the telephone after the opposing sides had met and general action had begun was another point to be considered.

(c). Only an officer who has been ahead can decide the amount of "clearance" necessary for the battery to "clear" the trees or other obstacles where our infantry firing line is likely to be held up. On the "clearance" is largely dependent the position for the battery.

If the position of the battery in action was not chosen by an officer who knew the conditions ahead he might find the position quite unsuitable.

(d). It must be remembered that when engaged with an enemy fighting a rearguard action, and the advance may be resumed at any minute, it is far simpler laying out telephone wires backwards i.e. from the advanced position back to the battery. On the resumption of the advance wire so laid out can be wound in as the force advances instead of the reeler having to go forward and wind it up in the reverse direction of the advancing troops.

There will be little doubt as to the line to be followed by the reeler if he keeps on the outskirts of the route used by the advance guard. He will be able to keep in touch with his own force and his

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unit in particular. This is possible when the F.O.O. is himself the officer who has been ahead. I will take it for granted that the Artillery Reconnaissance Officer has geen chosen to be the F.O.O.

3. The Advance for the Attack.

The F.O.O. having been detailed, he advanced with or behind the Infantry Firing Line, with his staff, and occupied the observation post previously selected or changed it if necessary, connecting it up with the spare reel in charge of the telephonist who had been left behind with orders to keep a good look out for developments.

To exemplify the following it has been taken for granted that the worst conditions prevailed and that the country was thick bush where nothing could be seen more than 100 yards either way except in the direction of the enemy where there was invariably an attempt at a natural or artificial clearing. The problem before the F.O.O. was to direct the fire of the battery on to the enemy's firing line which he had located by sound and partly by sight. The procedure was to draw a topographical plan of the relative position of Battery Observation Post, and Target, by which means the final magnetic bearing Battery-Target and Range was obtained. No reliable large scale maps were available.

The procedure was as follows. The squared paper on the back of the refills of A.B. 155 was used, a prismatic compass, liquid if possible, and semi circular protractor, marked with a degree scale 0° to 180° on one side and 180° to 360° on the other, arranged in this manner so that mistakes of 180° in plotting could not be made. To plot angles greater than 180° the protractor had to be turned over, when angles reading from 0° to 180° were seen reversed and so ignored and vice versa. On the protractor were also suitable scales for plotting ranges, about 3 inches to a mile.

In hilly country a pocket clinometer was found useful, but as a rule in hilly country aiming points visible both from the Battery and Observation Post were available, and then there was little difficulty as regards the invisibility of the target and observation post from battery. A pocket aneroid was also of use.

The F.O.O. on leaving the battery proceeded to take a bearing in the required direction and pace out the distance, this he continued to do, as in making a Field Traverse, until he had reached his destination.

He then plotted onto the squared paper in A.B. 155 the course he had come, thereby obtaining the relative position Battery-Observer. He then proceeded to take ranges and bearings to his various targets which he likewise plotted out on to this squared paper. By joining B to the various targets T^1 T^2 their bearings and ranges from B could be worked by the scales and protractor. (See Diagram I).

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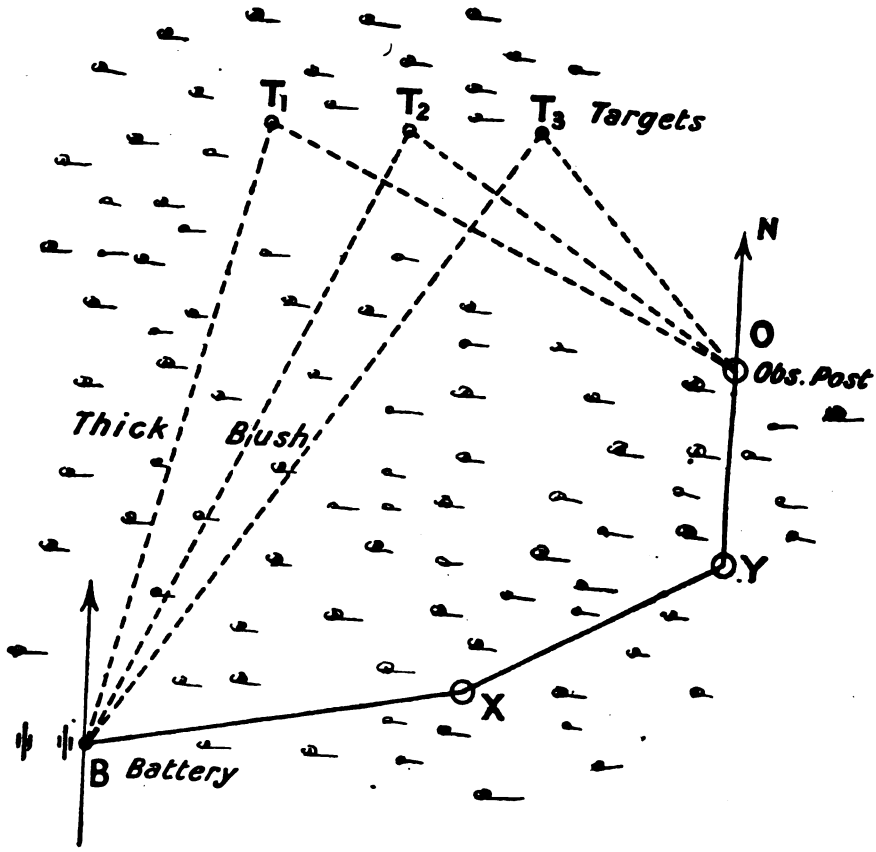

Diagram I.

Flat Bush Country where no visible Reference Points were available—necessitating a Field Book Traverse to obtain the relative positions of B and O. X Y being points on the traverse.

On a suitable target offering itself the F.O.O, proceeded to Range on the target firing a succession of trial rounds with high corrector which ballooned in the air, and enabled the F.O.O. to observe them. The corrector was then reduced and deflection and range were altered by degrees until the suitable range and fuze were obtained.

This way sounds a very lengthy and slow process but it was not so in experienced hands, and the worst possible instance has been taken which does not always occur.

To enable a routine to be followed as a *memoria technica* the following form was drawn up. (See Diagram II).

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To	Bearing & Range From Battery		Bearing & Range From Obs. Post.	
X				
Y				
T_1				
T_2				
T_3				

Diagram II.

If common reference points visible from both the Battery and Observation Post existed it was all the easier as the traverse was not required. Bearing and ranges were taken at the Battery towards one or more Reference Points and again on arrival at the Observation Post; these were plotted on the squared paper which gave the relative position B.O. Then on plotting out the position of the Target the bearing and range Battery-Target were obtained. The above aiming points had to be within the range of the range finder if they were to be used for plotting on the squared paper. (See Diagram III).

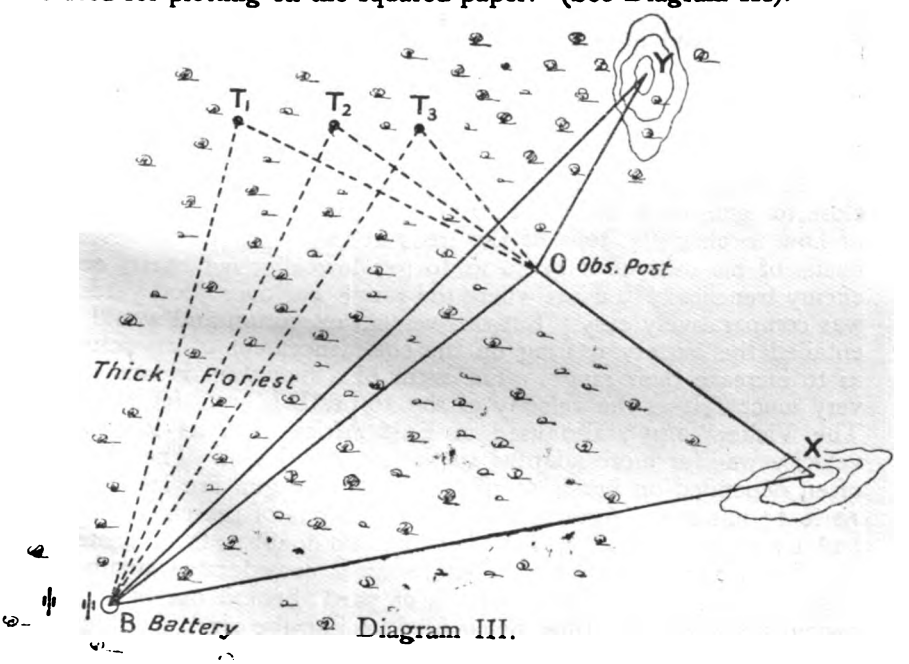

Diagram III.

Forest country where reference points X, Y, such as Kopjes were visible both from B and O. The relative position of B and O being obtained with reference to X and Y.

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Telephone wires when marked off into hundreds of yards could often be used as a check on distances which had been paced out.

While on the subject of laying out wire experience proved that through communication was the exception rather than the rule. Wire laid on the ground where there was grass was almost invisible and so was constantly being broken by stray animals and men coming to and fro. This was due to its not being laid high up on to the branches of trees; which was simplicity itself by means of any form of collapsible stick.

In the firing line this perhaps could be excused owing to the exposure of the reeler, but once under cover or out of sight the wire must be raised. With a high wire breaks were only possible from bullets; in which case the break was instantly seen and mended.

Owing to the excessive invisibility of the enemy's position it was found that only by constant and careful observation through field glasses could any sign of the enemy machine guns be discerned in the dark shadows under trees and bushes. These were sometimes given away by the faint, hazy smoke proceeding from the muzzle of a machine gun in the act of firing, or by its continuing in action too long after dusk when the flashes could be discerned. Such observations could only be made from a well chosen and well built observation post. Large tree trunks and anthills although very liable to draw fire were also a protection and there was a great temptation to use them as a basis for an observation post. In an open forest or bush these natural objects were not so conspicuous as one would imagine. A periscope and light shield for the F.O.O. were useful adjuncts, the latter repeatedly saving the life of the F.O.O.

The Fire Action.

In forest country the opposing infantry firing lines drew very close to each other and the F.O.O. was presented with the problem of how to clear the tops of the trees at the "target end" over the heads of his own infantry so as to get low effective bursts on the enemy trenches. In cases where the range was over 3000 yards this was comparatively easy. But this was an exception and would have entailed the battery retiring on the commencement of an action so as to increase their range. The want of a mountain Howitzer was very much felt as the velocity of the 10-pr. B.L. was far too high. The Vickers 2/95", also used in East Africa with its low muzzle velocity was far more adapted to the African Bush. The Germans often depended on bursts of rifle and machine gun fire lasting from 10 to 15 minutes. Against these a few rounds of searching gun fire had a very quieting effect, and there was no doubt as to its unsteadying the fire of the enemy's Askaris as a considerable number of casualties occurred many hundreds of yards behind our firing lines owing to the enemy's rifles being fired up into the air. The German machine guns, which were very well served by Europeans, were provided with the shields, and proved almost invulnerable from the effects of our rifle and machine gun fire. Against these only artillery fire was effective.

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In between those bursts of fire on the enemy's part it was not unusual with the exception of snipers to get a period of calm. This was the opportunity for the F.O.O. to collect information from the infantry either by going actually up to the various posts of the line, if this was possible, or by receiving weighted messages thrown from man to man.

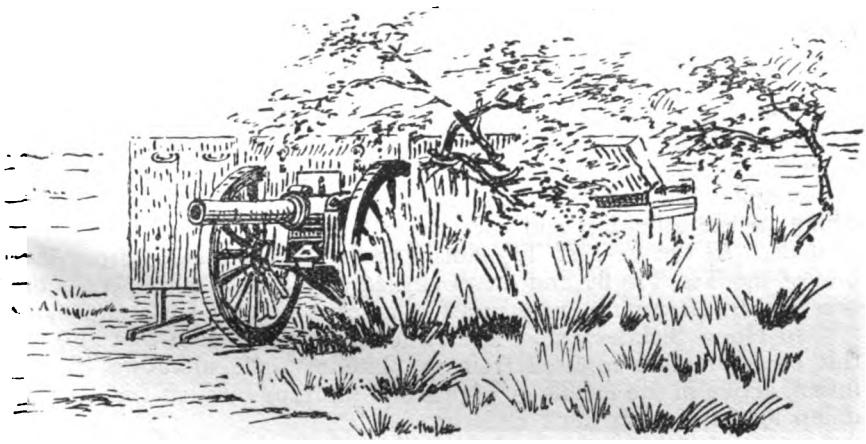
Sometimes a F.O.O. was able to locate the actual position of an enemy machine gun, but owing to the difficulties with the clearance, it was impossible to bring a sufficiently accurate fire to bear on it.

On these occasions when cover from view existed, it was found necessary to run up a mountain gun by hand into the firing line.

On arrival in East Africa steps were taken to provide the 10-Pr. B.L. equipment with side shields and a centre shield which fitted over the axle. On the front of these shields loops were fitted into which small branches of trees could be placed and so screen the gun almost entirely from view. By this means it was possible to run guns up into the firing line without their being spotted and within 200 yards of the enemy's firing line.

10-PR. B.L. GUN IN OPEN COUNTRY.

SHOWING THE EFFECT OF A SCREEN OF BRANCHES AND LONG GRASS ON ONE SIDE SHIELD ONLY.



The Breaking off of the Fight.

It may seem strange to treat this under a separate heading but it is done as a warning that the comparative quietness on the part of the enemy at nightfall did not by any means imply that he had retired. This frequently took place, and on the supposition that the enemy had retired we did not take full advantage to improve existing positions or to push forward. It was more than probable that the enemy ceased firing so as not to give away his position or that of his machine guns by their flashes. On the other hand the enemy profited by the interval to improve their trenches sometimes refusing

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to be driven out of their position till the 3rd or the 4th day. Finally the engagement was broken off about nightfall and the retirement effected after dark and unmolested.

II. Transport.

The most suitable form of transport was undoubtedly Pack.

The mountain batteries came over from India with their full complement of mules which enabled them to always have their 1st, line transport with them as part of the battery.

In the first part of the campaign the 2nd line transport consisted of ox wagons which were not half as satisfactory as having mules as was done later when they were given A.T. carts.

The first line pack transport enabled the mountain batteries to be always available and able to proceed with an infantry column whenever and wherever they might chose to go, and they were often cut off from their 2nd line transport for weeks at a time. This should be remembered, in our days when the increasing tendency is to reduce the number of mules in the batteries.

III. Prevention of Diseases.

Malaria was the worst enemy of the troops, and without a doubt could have been greatly reduced if a suitable pattern of mosquito net had been issued from the beginning and if the regimental officers had insisted on the men using it. In units were this was done the good results were very noticeable.

As regards the animals, two deadly diseases had to be contended with:

(a). Horse sickness.
(b). Trypanasomiasis (Tse. Tse. Fly Disease).

Both these diseases caused great havoc among the equines and transport animals of the Force. Here again it was noticeable what an enormous difference there was in the number of casualties between the irregular units and the more highly trained and disciplined units owing to the attention and care these latter could bestow on their animals. In the case of Trypanosomiasis, infection came from the bite of the Tse Tse fly and death ensued as a rule about 6 weeks or two months afterwards, only in a few cases was death instantaneous.

In Horse Sickness, most authorities held the opinion that also in this case infection resulted from the bite of some unknown biting insect, active in the evenings, nights and mornings, which frequented damp localities with thick undergrowth.

The precautions were roughly as follows:

1. Cutting the animals fodder, by day, if possible, and not letting them graze in Fly infected bush, and swampy grounds subject to Horse Sickness.

2. Choice of elevated camping grounds as free of bush as possible. When in Fly infested country to pass through it on as narrow a front as the tactical situation permitted.

3. Clearing camping grounds and lighting smudge fires of green branches and grass; together with the close picketting of the animals.

4. When the Supply Corps was able to issue Kerosine, an emulsion was made with Kerosine soap and water. The drivers were

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provided with dusters which were soaked in the emulsion and these applied to the more remote part of the animals under the belly and between the legs and under the neck, and especially in the parts devoid of hair.

5. Insistence on the immediate removal, or better still, the destruction of the Tse Tse fly, when seen on an animal. This may seem a platitude, but it must be borne in mind that the flies in parts were very numerous and that only at the expense of considerable trouble and additional fatigue to the men on the line of march was this possible. To destroy a fly even after it has bitten an animal is most necessary as it may often mean the life of many others, for it is by biting infected animals that the flies themselves obtain the disease and transmit it to others.

When in tick infected districts and not actually on the march, the animals were sprayed twice a week with Cooper's Sheep Dip, which kept them free of ticks and improved their condition considerably. It is however open to doubt whether this is advisable, unless it can always be done, as it weakens the animal's subsequent power of resistance to disease. During stables great care was taken to have all ticks removed.

The batteries carried about their own canvas watering troughs in the 1st line, which enabled the mules to drink clean water, often from the same pool as the men's drinking water. When only one pool existed animals of other units had to wait until the men's water had been drawn after which the animals were allowed to proceed to the pool and get into it. In the space of a few minutes the pool would be turned into liquid mud with the result that many animals got no water at all.

It is possible that in no previous British campaign have mountain batteries done so much continuous marching. The amount of grain received from the Supply Corps during a certain period of six months could not have averaged more than half a pound a day per animal.

It was wonderful under these conditions how such animals as the large Mountain Battery stamp of mule kept up their strength.

The greatest care was taken to spare the mules as much as possible, saddles being taken off if a halt longer than 45 minutes was ordered. On arrival in camp the saddle was taken off immediately and the pressure on the back taken by the blanket and roller. This was contrary to the usual mountain battery practice of keeping on the saddle with loosened girths for at least half an hour. The good, results, however, and the extra rest the animals obtained by doing this fully justified the practice, and undoubtedly enabled them to retain their strength through the vicissitudes of the campaign.

Lack of attention and provision for the welfare of animals was largely the cause of the heavy mortality amongst them. Regular units of many years experience and especially the mountain batteries had cause to congratulate themselves, on the comparatively small number of men and animals that they lost from sickness and disease. This was undoubtedly due to the unceasing efforts on the part of the personnel and also to the experience gained in the earlier part of the campaign in East Africa.

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SUGGESTIONS FOR THE EXTENDED USE OF TARGET RECORD DIAGRAMS.

By Lieut. A. G. Church, R.G.A. and R.F.C.

Scope of suggestions.

1. Choice of exact arbitrary point as origin, instead of the nearest exact co-ordinate to gun position.
2. Use of diagram for giving corrections for line and range, to all guns of a battery.
3. To enable Battery Commanders to control detached sections or isolated guns.
4. Use for Group Commanders for central control.
5. Use by observation and ranging Officers.

Generally.

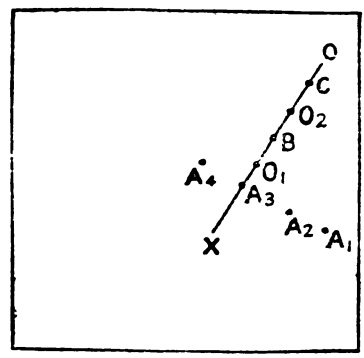
To supersede the present method of approximate calculations, by more exact graphical method.

Suggestions for more extended use of Swayne's Target Record Diagrams.

1. In the instructions for use it is assumed that it is most convenient to take the origin at the point of a square most approximate to the true position of the Gun.

Consider the diagram below, which can be taken as 500 yds. square on $\frac{1}{10000}$ map.

See accompanying diagram.



Let O X be the Zero line and A_3 the Gun position.

The line X A_3 runs through O_1 which is at the point a 7.5½; or suppose B is the gun position—then either O_1 at a 7.5½ or O_2 at a 8.7 could be used as Zero point for the battery.

The diagram could then be divided into squares corresponding to the map, and the position of A_3 B or C, as the case may be, marked on each square.

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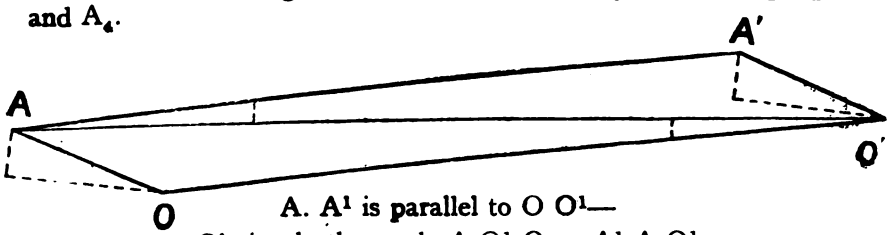
In precisely the same way, the other guns of the battery could be marked on the diagram in their exact relative positions—A_1, A_2, A_3 and A_4.



A. A^1 is parallel to O O^1—

Obviously the angle A O^1 O = A^1 A O^1

Corrections for line and range can be read off from the diagram, obviating the necessity of using formulæ for calculating corrections for displacement, which at best are only approximate.

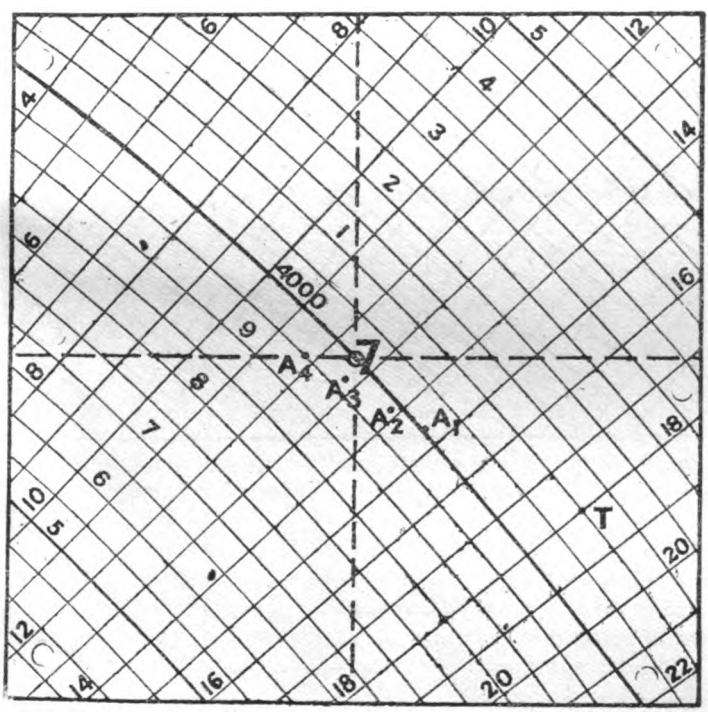
Example I.

Target O 7 D 65.55.

Range from Zero point = 4100
Switch " " " = 18°R

Corrections to guns.

	Line.	Range.
No. 1	2° L	Nil.
No. 2	1° 10′ L	Add 20 yds.
No. 3	10′ L	Add 40 yds.
No. 4	50′ R	Add 50 yds.



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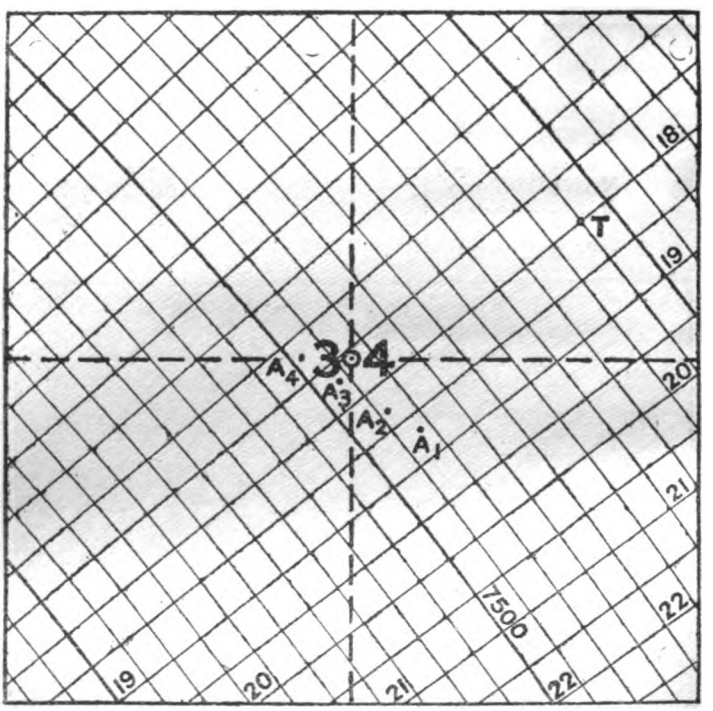
Example II.

Target I 34 b 65.40

Range from Zero point = 7950
Switch „ „ „ = 18°R

Corrections to guns.

	Line.		Range.	
No. 1	1°	L	Drop	10 yds.
No. 2	35′	L	Add	10 yds.
No. 3	5′	L	Add	50 yds.
No. 4	25′	R	Add	60 yds.



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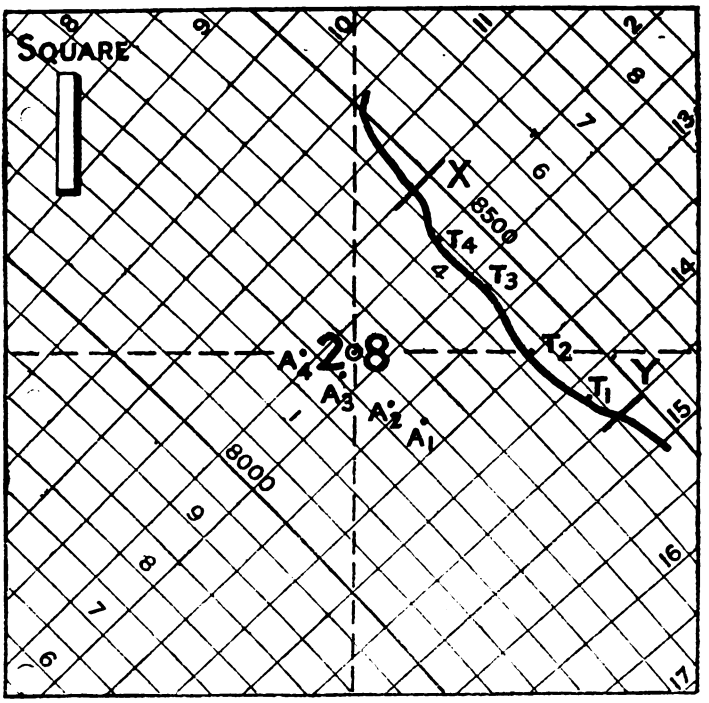
Application to Distribution of Fire.

Suppose it is required to distribute the fire of a 4 gun battery over the Section of trench X Y in I 28.

Assume T_1, T_2, T_3, T_4 are the points engaged by A_1, A_2, A_3 and A_4 respectively



Apply corrections to each gun at its respective target.

	Line.	Range.
No. 1	14° 12 R — 1° L = 13° 12 R	8440
No. 2	13° 30 R — 40′ L = 12° 50 R	8420 + 25 = 8445
No. 3	12° 45 R — 5′ L = 12° 40 R	8445 + 45 = 8490
No. 4	12° 15 R + 20′ L = 12° 35 R	8445 + 55 = 8500

It is sometimes necessary for a battery to occupy an alternative position. Providing the same aiming point could be used, or the guns layed parallel to the original line of fire, and the new position plotted on the diagram—the previous registrations could be used.

Use for Detached Sections.

With the larger calibre guns, B.C's could effectively control the fire of detached sections. If, for tactical reasons, it became necessary to shift a gun to a temporary position, the new gun position need onlv be plotted on those squares in which the targets are situated.

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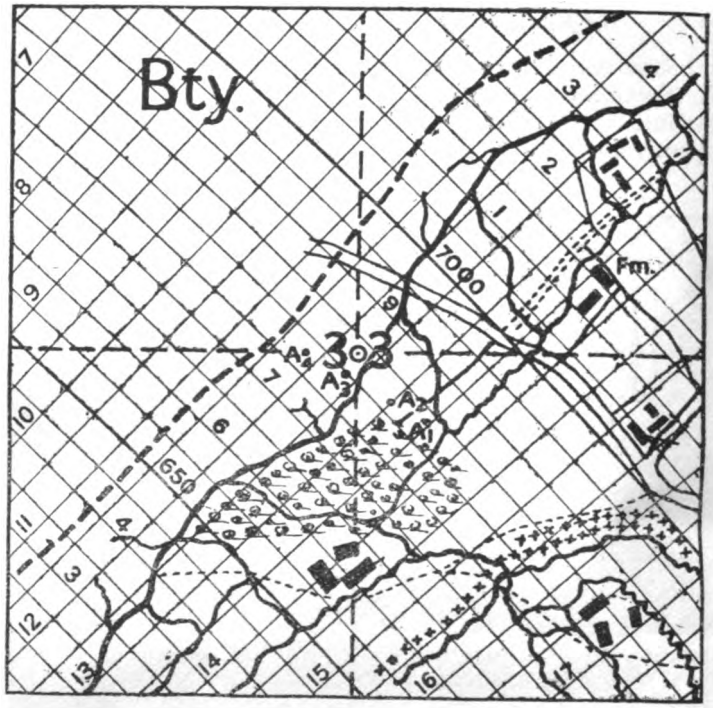

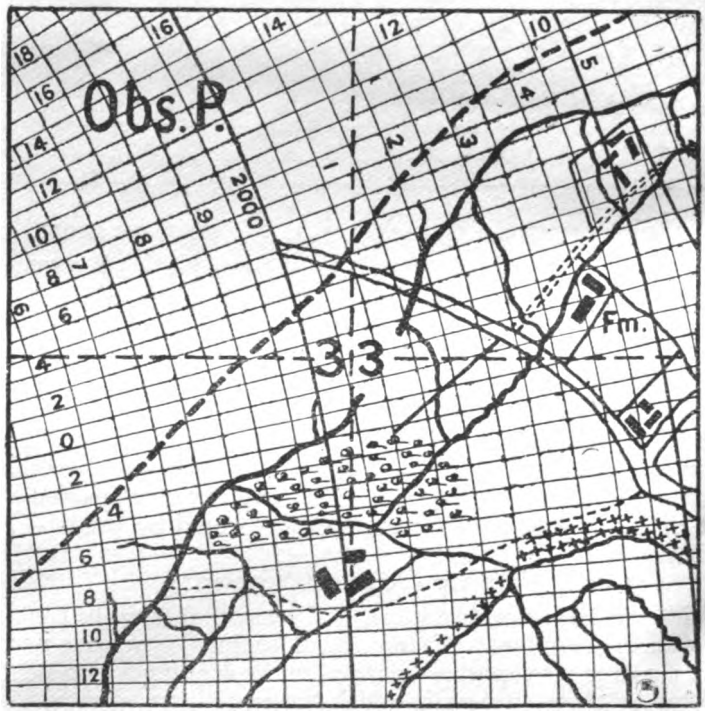

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Group Control of Field Batteries.

Assuming the normal frontage of each battery were small, a group Commander might use the diagram for central control of fire with advantage—more particularly if Balloons were used for observation of fire.

In an advance, telephonic communication is far more likely to be broken between f.o.p's and battery than between group Headquarters and the batteries.

Use by Observers in O.P's.

Consider the Square 33 which may be taken to represent some enemy defences. The angles and ranges we can assume to be from our zero point.

Suppose the observation post to be 1500 yards from 33 C

Trace the principal features on a square corresponding to 33 from the O.P.—accentuate every 5° from the O.P. In ranging the battery, observations can be immediately converted into battery corrections by comparison between the battery and the observation squares.

Attention to the landmarks will often enable a ground observer to guage accurately the necessary corrections for range, as well as line.

This method possesses advantages over the calculations of corrections by Ranging on Line of Observation—the latter method contains many pitfalls when the range of the Target from the O.P. is very small, compared with the battery range.

Suppose the target is the farm at 33 b 7.2. Imagine the first round fired falls 2° L to Observer, and just in front of the hedge, about 100 yards plus.

If ranging on the battery line, the line is correct, and the range about + 150.

If ranging on the line of observation, the corrections to battery will be 30′ L, shorten 200 yards, unless it is thought desirable to correct for line only on this round.

This method is obviously better than any other for converting observations from a balloon, for with balloon observation, the fall of round can often be seen and accurately co-ordinated by the Observer.

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WIND-CLOCK.

Description of Wind-Clock to show Range and Deflection Corrections required to compensate for a given wind blowing at any angle to Line of Fire at various Ranges for Guns of fixed armament.

By Captain H. G. Willmot, C.G.A.

THE Clock consists of a circular board covered with drawing paper upon which are described a series of concentric circles with radii at every 10°.

The radii representing the horizontal and vertical lines cut the circles into 4 segments of 90° each and these lines are made more prominent than the others.

The upper end of the vertical line terminates in an arrow head pointing upwards and is marked line of fire.

The outer circle is drawn 3″ to 4″ from the edges of the board, and the radii at their points of intersection with the circumference of this circle are marked 0°, 10°, 20° up to 90° in each segment. 0° is always on the vertical lines and 90° on the horizontal.

Each space between the circles corresponds to a definite range which is shown on the horizontal and vertical lines. Any number of circles may be employed but 5 circles giving 4 spaces (and thus 4 ranges) will generally be found sufficient.

Ranges should vary from short to extreme, e.g. 2500, 5000, 7500, and 10,000 yards for a gun of which the latter is extreme range. Ranges run outwards, viz: Space for shortest range is nearest centre.

In the portion of each segment of 10° corresponding to a particular range is entered the range correction + or − and the deflection R or L necessary to compensate for a wind of the given velocity making the angle indicated by the radius of that segment with the line of fire. Thus in segment lying between 0° (line of fire) and 10° are entered the corrections for wind at 10° to line of fire (for the 4 ranges); in next segment (between 10° and 20°) the corrections for wind at 20° to line of fire, and so on up to 90°.

To avoid complications only one speed of wind is taken into account, 20 f.s. being a convenient one, other speeds giving proportionate corrections.

The actual corrections for a wind of the speed selected are worked out by formula from calibrated angles and muzzle velocities or corrected range tables, and are entered in the proper segments for the selected ranges.

Range corrections falling in segments above 90° (horizontal) line will always be *minus* and those below, *plus*; while deflection corrections falling in segments to right of 0° (vertical) line will be 'left' deflection and those to left of line, right.

The signs + or − are prefixed to range corrections and deflection corrections followed by R or L. Corrections in any segment will always be + or −, and R or L as the whole of the circle is marked.

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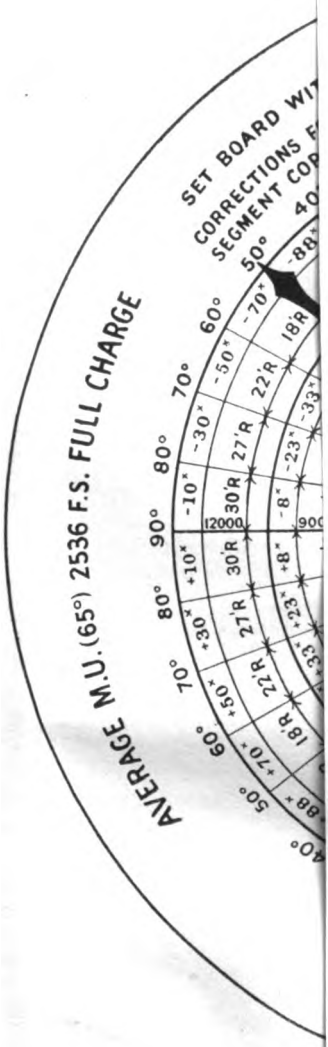

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It follows that corrections in diagonally opposite segments will always be the same but with opposite signs.

Different coloured inks should be employed for range and deflection corrections.

The board may be of any size, but having regard to the fact that radii are only 10° apart, should be large enough to enable corrections for the shortest range to be read easily. A suitable size of board for a clock showing corrections for 4 ranges is 24″ diameter having the outer circle of 18″ diameter.

The 3″ margin is reserved for notes as to height of battery, muzzle velocities, etc., etc., and the Admiralty Wind Scale is a useful addition. Concise directions for use of clock should be entered on this margin.

After all data are entered the face of the clock should be sized and varnished.

The board has a circular hole of 1″ to 2″ diameter in the centre (the inner circle being kept well clear of this hole) which fits over a hardwood pivot fixed in a convenient place in or near the B.C. Post, the board being capable of being revolved in a horizontal plane about the pivot. (For high sited batteries a ball and socket joint for the pivot might be provided or it might be set at an angle).

The pivot projects slightly above the surface of the board and has a metal pin of ¼″ diameter screwed into the top of it, having at the upper end a screw and butterfly nut. This pin carries a narrow metal clock hand equal in length to the longest radius, having an arrow point. The hand moves freely on the pin and is easily detachable, but can be clamped in any position by the butterfly nut. The hand when in position is about ¼″ above the clock face. Board and hand can be revolved independently of each other.

Method of use.

The clock is placed on the wooden pivot and the clock hand placed on the metal pin.

The direction of the wind having been ascertained the clock hand is given the same direction (pointing down wind). The hand is clamped in that position.

The board is then rotated until the arrow head (line of fire) points at the target.

The corrections for range and deflection for the different ranges are read in the segment immediately under the hand.

The accompanying model shows the working of the device. The figures given do not refer to any particular gun.

It is claimed that the device has the following advantages:—

It is simple to construct and to use and practically does away with all calculations, thus eliminating errors and waste of time.

Range Tables and Slide Rules are not required.

The wind angle is automatically resolved and any alteration in angle due to travel of target or to a switch to another objective only involves rotating the clock face to obtain the necessary correction. As corrections are worked out for every 10° of angle, greater accuracy is obtained than by taking ¼, ½, or ¾ of full effect as is generally done in practice.

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ON CLEARANCE.

By Lieut.-Col. H. W. Hill, D.S.O., R.F.A.

In the field, it is frequently required to determine rapidly whether or not a certain target can be engaged having regard to the position of trees or the location of our trenches which may be on higher ground than the point to be attacked.

A rapid and simple solution is as under:—

Determine the Quadrant Elevation to (T) the target to be engaged, and to (Z) the possible obstruction in the trajectory.

The clearance in degrees and minutes is then found by subtracting the Q.E. to (Z) from the Q.E. to (T).

Example. (With 18-pr. Q.F.).

Gun Range to T.	= 3000 yards	=	5° 1′
Angle of Sight to T.	.....	=	−0 25
Q.E. to T.	.....	=	4 36
Gun Range to Z.	= 2600 yards	=	4° 7′
Angle of Sight to Z.	.....	=	+0 5
Q.E. to Z.	.....	=	4 12

Hence Clearance = (4° 36′) − (4° 12′)
= 24 minutes.

That is to say that the mean path of the trajectory will pass 24 minutes above Z as measured from the battery.

Clearance is most conveniently determined as an angle in degrees and minutes, the safety limit can then be more easily applied.

The following rule may be found useful in determining safe clearances for the 18-pr. Q.F.

Rule. The safe clearance in minutes is found by halving the number of hundreds of yards in the range to the target (T).

Hence at a range of 3,000 yards, the minimum clearance should be 15 minutes; and at 2,000 yards range, 10 minutes.

This rule is based on the data in the following Table.

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18-Pr. Q.F.

Range in Yards.	Minimum Clearance	Clearance in Yards.	50% Length Zone	100% Length Zone for Rounds short of Target.
2,000	10′	90 yards	22 yards	44 yards
3,000	15′	100 ,,	31 ,,	62 ,,
4,000	20′	120 ,,	38 ,,	76 ,,

It will be seen that the above clearances should generally be satisfactory provided that all the guns are shooting well together and that the data for the calculation of the Quadrant Elevations are known exactly.

With these clearances it might, however, be advisable to clear the front line trenches, particularly during ranging, which should be carried out by a process of creeping back.

For greater safety, the clearance in minutes can be taken as equal to the number of hundreds of yards in the range. With such a clearance it should be unnecessary to clear the front line trenches.

The actual height in feet of the mean trajectory above Z is given by the formula

$$H = \frac{M \times R}{12}$$

Where H = Height in feet.
M = Clearance in minutes found by subtracting the Q.E. to (Z) from the Q.E. to (T).
R = Range to (Z) in hundreds of yards.

Example.

M = 24 minutes.
R = 2,600 yards.

$$H = \frac{24 \times 26}{12}$$

= 53 feet.

NOTE.—In the field, the value in degrees and minutes of the target elevation for the ranges to (Z) and (T) can be obtained from the range dials which are graduated in degrees and minutes as well as in yards.

In the Field,
May, 1917.

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INTERIOR BALLISTICS.

Simple facts and formulæ.

By Lt.-Col. R. K. Hezlet, D.S.O., *pac.*, R.F.A.

Published in the "Journal" of the Royal Artillery Institution, June, 1917.

ERRATA.

Page 104 line 28 for " ;" read " ,"

Page 105 line 8 from bottom for

$$\frac{S}{d^3} \quad \text{read} \quad \frac{S}{d}$$

Page 107. Calculation at bottom of page for

$$G,\ S,\ \frac{1}{W},\ \frac{1}{M},\ \frac{1}{L_1} \quad \text{read}$$

$$G_1\ S_1\ \frac{1}{W_1}\ \frac{1}{M_1}\ \frac{1}{L_1} \quad \text{throughout}$$

Page 112 footnote for "27·7" read "27·7 $\frac{M}{G}$"

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August, 1917.

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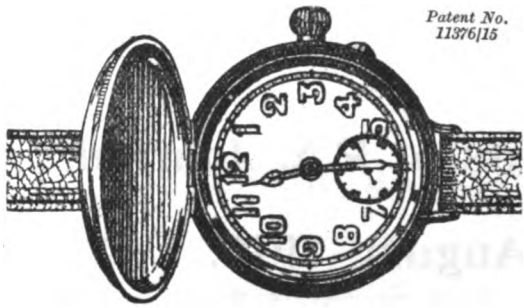

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THE TRAINING OF SENIOR N.C.O's AT THE FRONT.

By Major P. R. Sargeaunt, R.G.A.

WHEN a battery is in action it is usually considered necessary that there should be at least one officer with the guns and another at the O.P. The majority of batteries in France are now well supplied with officers, but a time may come when officers are not so plentiful as they are at present, and it seems advisable to be prepared for such a time.

In the French Artillery N.C.O's receive sufficient training to enable them to fight a battery, and the writer has heard French officers compare our artillery unfavourably with their own for the reason that our N.C.O's are usually incapable of taking charge and fighting the battery in the event of their officers becoming casualties. Now there is no reason why this should be so. Every senior N.C.O. should be a potential officer, at least as regards the actual fighting of the battery. During Trench Warfare there is ample time available in which to train N.C.O's sufficiently for this purpose, and it is proposed to consider the general lines on which this training should be conducted, and the best method of carrying it out.

It is not intended to suggest that a Battery Commander will at all times be able to carry out a system of training when his battery is in the line. During active operations it would be out of the question; but in the lives of most batteries there are periods of semi-inactivity on a quiet sector of the front, when there is ample time for this training, and if it entails a certain amount of trouble the results attained should be sufficient compensation.

The first points to be considered are the subjects in which the average N.C.O. will require instruction before he can efficiently take charge of the battery and carry out work which is normally performed by the Battery Commander and his subalterns. These subjects are really very few, and may be roughly summarized as follows:—

(1). Director work and laying out Lines of Fire.

(2). Ranging.

(3). Map Reading.

These three headings will be discussed separately with a view to seeing the best manner in which they may be taught. Certain minor points and side issues will appear in connection with each, and these will be dealt with as they occur.

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(1). Director work and laying out Lines of Fire.

All N.C.O's should be able to use the director, but owing to the rapidity of promotion in many batteries on active service, and to the lack of opportunities for training, it is the exception to find N.C.O's as proficient as they were expected to be in peace time in this respect.

Section Commanders should be made responsible for this training, and they should have no difficulty on days when they are off duty in holding small classes of instruction for, say, the Sergeants and Corporals of their sections. All that is required is that the N.C.O. should fully understand the director and all operations connected with it. The word "fully" is important. Simple instrument that the director is a few searching questions will often reveal the ignorance of N.C.O's, and even of officers, in the working of it.

The various methods of laying out lines of fire must be taught, and the mysteries of the compass and rites in connection with T.O.B. explained. A little enterprise on the part of subaltern officers will tend to render this instruction more interesting. For example in laying out lines of fire by the T.O.B. method a known point on the map can be selected for O (which for obvious reasons should not be in view of the enemy for instructional purposes), and an object picked up which is visible from O and in line with some target in the arc of fire of the battery. The range and angle of sight along OT can be given from the map by the Instructor, and one or more of the class allowed to get the battery onto the target. Then, by comparing the line and range on the guns with that given by the map, the accuracy or lack of accuracy with which the operation has been conducted will be apparent.

After a few days instruction every N.C.O. should be capable of laying out the lines of fire of a battery by any method, and of deciding the best method to make use of according to the situation.

(2). Ranging.

This perhaps presents the greatest difficulties as regards instruction. At the same time it is of the greatest importance and cannot possibly be neglected if the desired end is to be attained, that is to render N.C.O's capable of fighting the battery. Only by actual practical and personal experience can efficiency in ranging be arrived at, but much can be done in the way of preliminary instruction.

In the first place the general principles of ranging as laid down in F.A.T. must be thoroughly inculcated; too great a stress cannot be laid on the importance of a thorough grip of these principles being obtained before any attempt is made to put them into practice.

It is not proposed to discuss the rival merits of different methods of ranging; Battery Commanders have their own ideas on the subject, and will no doubt wish to impress on their N.C.O's the advantages of their favourite methods. But the elements of ranging as set forth in F.A.T. must be mastered by all.

The next step will be for the pupil to see the principles he has learnt put into practice. It is not always possible to have N.C.O's at an O.P. as spectators, as for example when the O.P. is in a trench and observation has to be carried out by means of a periscope.

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But in many cases, such as when the O.P. is in a house, it can be managed. The N.C.O's can then watch series carried out by the Battery Commander or other officer, and should be made to record their own observations of the fall of each shot, and also the orders they would have given to the guns had they been conducting the shoot. At the conclusion of the series a discussion can be held, and the N.C.O's who have been observing should be encouraged to ask questions, especially as regards any orders which differed from those they themselves would have given.

But actual personal experience in Ranging is also necessary, and this is not easy for N.C.O's to obtain. At the same time it seems almost worth while to set aside a few rounds daily for this purpose, and as the N.C.O's gain experience they might be allowed to carry out actual tactical shoots. In fact it is important that they should do so, for in this way only will they acquire that sense of responsibility which leads to self confidence. But this will be referred to later.

Assuming then that a few rounds are allotted daily for instructional purposes, targets would be selected, and the N.C.O. or N.C.O's under instruction would range on them under the supervision of an officer, who however should make no remarks during the series unless it appears to him that ammunition is being wasted. The targets should be easy to start with, increasing in difficulty as the pupil became more proficient. It is not to be expected that N.C.O's will be capable of ranging the battery on any target after a few practice shoots; some officers are more successful in ranging than others, and it must be the same with N.C.O's. The operation of ranging appears simple at first sight, though in reality it is not so. But the officer who has had experience in ranging will be able to point out the pitfalls to be avoided, and, with perseverance, the N.C.O's under instruction should become sufficiently expert for all practical purposes.

(3). Map Reading.

Map reading is very simple, and this should be pointed out at the start. In Trench Warfare especially it is important to be able to identify points on the map with those seen on the ground, and this can best be taught at the O.P. In connection with this a proper appreciation of distance is essential; the tending to underestimate the range to a given point is one of the commonest mistakes of the beginner, and one of the first that should be corrected.

While on this subject it is worth while considering the great value during Trench Warfare of being intimately acquainted with all the country visible from the O.P. Every senior N.C.O. should be capable, as every battery officer presumably is, of switching the guns onto any target seen from the O.P., provided that it is within their arc of fire, without having to use a map, protractor or range scale.

In connection with map reading the method of getting the guns onto a target from the map must be taught, not only with the use of a properly constructed map board, but also by the method of using a right angled triangle of which the hypotenuse is the line B T.

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The above remarks are only intended to suggest an outline of the training that is required. There are other minor points on which instruction should be given, and these will readily present themselves to the Battery Commander. At the same time if senior N.C.O's are conscientiously trained on these lines any one of them should be capable of taking charge at the guns or at the O.P. in the event of the officer there becoming a casualty.

But there is one other matter that must not be overlooked: that is the importance of allowing senior N.C.O's a certain amount of responsibility in order that they may gain self confidence. A man may be quite capable of carrying on as long as there is an officer at his elbow and he knows that nothing really depends on him. But when the time comes for him to make some practical use of his training, when one or more of his officers are casualties and he is left in charge, then, unless he has acquired a feeling of self confidence, the probability is that he will lose his head, and the consequences will be disastrous.

So when a Battery Commander considers a N.C.O. sufficiently expert, he should occasionally allow him to carry on by himself both at the O.P. and at the guns. Battery Commanders will no doubt be loath to do this, but in no other way can our N.C.O's be expected to be ready to take the place of their officers.

We do not know how much longer the war will continue, but it is quite possible that before the end there may be a prolonged period of moving warfare. We must expect heavy casualties then, and we may have to look to our N.C.O's to fight our batteries. Then will any previous training they have received be found invaluable.

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HOW TO RANGE WITH AEROPLANE OBSERVATION.

By N.C.T.

IN the April number of the Journal an article appeared called "Artillery aeroplane ranging board" in which the author quite rightly condemns the "Artillery dial range corrector", but proceeds to make another instrument which is certainly a better one although rather cumbersome, as with Howitzers one is necessary for each charge; thus with 4 charges about 7 square feet of boards are required.

I venture to suggest that no special instrument at all is necessary.

The "Artillery dial range corrector", the "Plotter, aircraft, observation, Mark I", and the elaborate article on the market that can be bought for the mere trifle of 37s. 6d. are based on the 2 assumptions that (1) the B.C. at each round makes the exact correction for the observation, (2) that the observer can send down the exact position of the fall of each round with regard to the target.

As regards (1) the zones of the gun have of course to be considered and even if the plotted result was absolutely accurate, a B.C. does not necessarily give the exact correction, hence an instrument which states on it that because a round falls say 10 yards left and 40 yards short, therefore a correction of 10 yards right and plus 40 yards has to be made is faulty in principle and misleading. This is what the Artillery dial range corrector does.

As regards (2) the clock code precludes the observer being able to send down an exact correction. He cannot send down anything between two circles and between two hours, and therefore the observation, even if the round is most accurately observed, may be sent 50 yards out for distance and 15° for line.

For instance, presume the line of fire runs half way between 9 and 10 o'clock and a shot falls line and plus 200, at a range of about 8000 yards. This round has to be sent down as C IX or C X and will be plotted 40′ away. If the B.C. acts on this he will throw his line out by 40′. Apart however from this, there is the personal error of the Observer. No human being, flying at great speed, even if directly over the target and at the most favourable height for observing can accurately locate the position of a shell burst with reference to an imaginary line. The best observers will acknowledge that the result as sent down may be an hour wrong either way, and

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this is confirmed by the many series fired over ranges in England and measured up afterwards. In these series good observers were used, conditions were favourable, the same targets were often fired at, and there were no Archies or hostile aircraft to worry the observer.

To apply an exact correction is therefore folly, and if this is so, an elaborate instrument to plot the observation accurately is unnecessary.

The B.C. should bracket for range and line. As a general rule he should only correct his line if the round is more than an hour out for line, and his elevation if the round is more than an hour out for range.

Thus if the line of fire passes, say, through 2 and 8 o'clock, he should only correct his line if the round is reported on the 4, 5, 6, 10, 11 and 12 hours, and his range if on the 1, 2, 3, 7, 8 and 9 hours.

This makes ranging very easy indeed. It will be noted that for practical purposes, the same deflection correction is required for either 4, 5, 6 o'clock, or in the opposite direction for 10, 11 and 12 o'clock, and the same correction for range, for either 1, 2, 3 o'clock or in the opposite direction for 7, 8 and 9 o'clock.

Make a note at the top of the ranging sheet of the value of 100 yards (the B circle) in minutes of gun elevation and deflection. The C circle is of course double this and the A circle half.

Now all that is necessary is a watch to note the line of fire.

This can be marked if required on the glass face of the watch by means of a grease pencil (a special pencil for writing on glass or china, cost 4d.) but after some practice, many B.C's will find that it is not even necessary to mark the line of fire—12 o'clock is 0, 6 o'clock is 180°, and each hour is of course 30°.

Thus if the bearing is 237° mark the line of fire at 2 o'clock 8 o'clock.

If the line of fire does not pass exactly through an hour, mark the line of fire to the nearest half hour. If it passes through a half hour, how to act depends on the capacity of the observer, and whether observation is difficult or not. It is a question of whether the line should be altered if the round is reported as 1½ hours off the line of fire.

Thus—line of fire at 2.30—a round is reported as B. 4.

Should the line be altered? The answer is on most occasions, yes, but if the observer is inexperienced, new to the country or observation is difficult, it might be advisable to wait for a 11, 12, 5 or 6 o'clock result.

If the watch is considered too small or difficult to see, then a celluloid clock face placed at the required angle over the grid-plotter or over a plain or squared piece of paper with the line of fire marked on it is sufficient. Anything more elaborate is not only unnecessary and wastes time but may be very misleading especially to an inexperienced B.C. as it is a direct encouragement to make exact corrections.

NOTE.—The Boche when ranging by aeroplane pays no attention after the opening rounds to amounts plus or minus and right or left.

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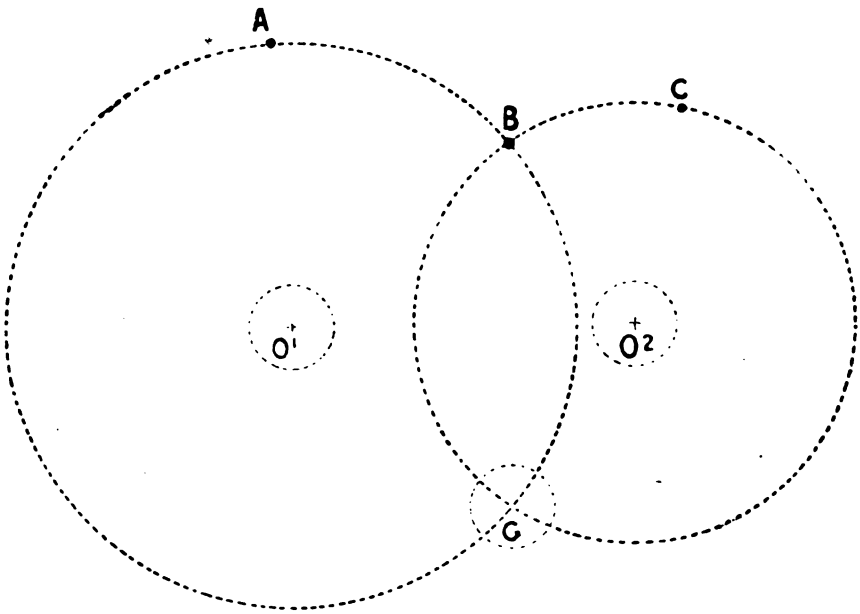
LOCATING POSITIONS ON MAPS.

By Captain R. C. S. Morrison-Scott, R.M.

In the "Journal of the Royal Artillery" for January last, Lieut. H. S. Rowell gives in an article "On Locating Positions on Maps," a method which he states is believed to be new. I have used for some considerable time a method based upon the same principles as that of Lieut. Rowell, but somewhat simpler to carry out, and perhaps less to open to error, as there are no lines to be drawn on the map, except a few small arcs, and no angles to be constructed.



$$O^1B = \frac{AB}{2\ (\text{Sine angle } AGB)} \qquad O^2B = \frac{BC}{2\ (\text{Sine angle } BGC)}$$

N.B.—The only necessary markings on the map are those surrounded by a dotted line.

A, B and C are the landmarks between which the angles are measured in the usual way with director, sextant, theodolite,

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prismatic compass or other available instrument. The method of locating on the map, the point from which the observations are taken is as follows. The distance between A and B, on the map, is measured in terms of any convenient small unit, millimetres or half-millimetres for instance,—the sighting rule of a service plane table, graduated on one edge to 1/50ths of an inch gives a convenient standard. The length thus found is divided by twice the sine of the angle observed between A and B, that is $\frac{AB}{2\ (\text{Sine angle } AGB)}$ This gives the length of the radius of the circle passing through A and B, and the point from which the observations were taken. Therefore with this length as radius, and A and B successively as centres, strike two small arcs intersecting at O^1. Then with O^1 as centre and with the same radius, describe a circle, which will be found to pass through A and B. Somewhere on the circumference of this circle will be found the point from which the observations were taken. Deal similarly with B and C, and the angle observed between B and C. This will give another circle cutting the previously described circle at a point G, which is the point required to be fixed, namely that from which the observations were taken.

At least three fixed points are of course necessary. A larger number will help to confirm the result, and would be dealt with in exactly the same manner; but three well-determined points should give a perfectly accurate location of the point of observation G. Since the approximate position of G is always known it is not necessary to draw complete circles, but only those arcs which run through the approximate locality. Thus the portions shown by dotted lines are unnecessary and can be omitted altogether.

It will be seen that the method is one of extreme simplicity, but great accuracy, involving only a very few markings on the map and avoiding the construction of angles, which is always a very considerable source of error.

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LOCATING POSITIONS ON MAPS.

By Lieut. H. S. Rowell, R.A.

WITH reference to the very interesting note by Captain J. Powrie, H.A.C., on the above subject in the R.A. Journal for May (page 68), the following word of explanation is due:—

The method given in my article as new was new to me. It was worked out in the desert to meet actual needs. It seemed such an obvious application of Euclid's 3rd Book, that I thought it must have been used before. It was shown to several experienced officers (both gunners and sappers) who had not seen it before, and considered it worthy of publication. After the proofs had been corrected I was informed that the method had been given already in a handbook published by Messrs. Gale and Polden. In any case I willingly surrender any credit for the method, which is, of course, a very easy rider on Euclid.

The secant-latitude correction for the azimuth of Polaris was omitted intentionally for the sake of brevity and simplicity The normal procedure, and, in fact, that followed as a rule by professional surveyors, would be to wait until the pole star is above or below the handle of the Plough (i.e. ϕ or ζ), and fix a North line by sighting with a director theodolite or aiming posts.

Orientation by sunrise or sunset must, so far as field service is concerned, be a rough approximation only. It would be very inconvinient to have to wait for an equinox and a sea horizon, and even then Captain Powrie's corrections would have to be supplemented by an allowance for refraction.

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ANTI-AIRCRAFT DEFENCES FOR COAST FORTIFICATIONS.

From the Journal of the United States Artillery, March—April, 1917.

By Major Thomas Q. Ashburn, C. A. C., U. S. Army.

IN the study of such a subject the first step is to determine what types of air-craft will be used, how they will be used, and what purposes they are designed to accomplish.

There are three conditions under which the defences may have to contend with hostile air-craft.

1. When the fleet has a sufficient number to gain control of the air.

2. When the hostile air-craft are approximately equal.

3. When the air-craft of the defences are powerful enough to control the air.

Under any and all of these conditions some one of the following objects is designed to be accomplished by the fleet air-craft:

1. To reconnoitre and discover the location of the various elements of the defences.

2. To control the fire of the enemy's ships against land batteries and defences, and hostile ships.

3. To bombard.

In these three objects three separate types of machines would probably be used:

For the first, scouting machines of the tractor-type, quick acting, capable of a speed of 80 miles an hour or more, unarmoured, unencumbered by wireless or guns, carrying not more than one or two passengers who are armed only with a rifle or revolver and provided with field glasses and photographic apparatus.

For the second, heavier and slower machines, capable of furnishing all necessary conveniences to the aviators, of great stability under slow speed, armoured sufficiently to resist rifle attack, and fitted with sufficient armament to repel "scout" attacks.

The third class should be speedy, easily manœuvered, all steel covered (if practicable), capable of carrying sufficient guns to meet a destroyer on even terms, and equipped with bombing material.

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In the discussion of any project for defence, it is wise to consider that the enemy has been able to limit the defence as much as possible, and to devise ends and means to meet such conditions.

If the lesser unfavourable conditions are actually what occur, so much the better for the defences; and if the defences actually gain the supremacy of the air, then a formidable menace is greatly reduced.

We will, therefore, assume that the enemy has gained control of the air, but that the defences still have a few machines of all types available. This is really a fair assumption, because at the present time our aerial equipment is decidedly inferior to that of any powerful foreign nation, and while Congress appropriated liberally in the last year for aeroplanes, etc., and an organization into units has been started, it will be some time in the future before we can hope to cope in war times with a foreign invader.

Let us consider a defence against the scout type first.

What can a scout do?

No material damage; for it is a light machine, unarmoured, easily handled, and rarely carrying more than two men. It can, however, do very substantial damage in locating the various elements of the defence if unmolested.

How close must they fly to the defences to obtain accurate information?

Of course that will depend upon the condition of the atmosphere; whether or not there are clouds, rain, snow, or fog.

Under favorable conditions, the least limit to which the scout plane must descend is the distance at which the telephoto-lens cameras make pictures sufficiently clear to be enlarged so as to show the terrain conditions, or where the observer can distinguish clearly enough by his glasses to make a sketch. At the beginning of the war, photographs and sketches were made at distances from 500 to 2000 feet. The limit at which they are now made is practically 5-6000 feet, but may be as high as 8000 feet and perhaps more. The vision from air-craft, however, is greatly impaired by the slightest haze.

As the limit of the use of the scout has increased, the effective range of air-craft guns, and their handling, has more than kept pace, and to-day, according to an eminent English authority, and to our Signal Corps reports, "the development of anti-aircraft artillery has reached a point where it is decidedly uncomfortable for an aviator to fly lower than 10,000 feet." The United States considers that the "safe" altitude is not less than 12,000 feet. The use of aeroplanes at night for purposes of scouting or reconnaissance are so confined that the question of defence against them at night is superfluous, except to keep under cover as much as possible and to use searchlights judiciously.

Let us now consider the destroyer class.

Their method of attack against seacoast fortifications is limited to bombing.

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According to the very best authorities obtainable, drop bombs are classified as light weight, medium weight, and heavy. The light weight bombs vary from a few pounds to 15 pounds, the medium weight from 15 to 50 pounds, and heavy bombs, which go no higher than 100 pounds in our service, may range as high as 220 pounds. In a few isolated cases bombs weighing as high as 400 pounds have been used. These bombs are undoubtedly designed to detonate upon impact and, while good reasons can be advanced for equipping them with time fuzes that would be ignited by the shock of impact, there would be the objection that the bomb would have to be heavier in order to have sufficient strength to resist breaking up on striking and before explosion could take place.

These facts, however, have probably caused the bomb makers to invent a combination impact and time fuze for, of course, the heavier the bomb, the more difficult it is to handle in the aeroplane and also the smaller the number that can be carried.

Everyone has seen an acrobat in a circus drop from the top of a tent into a net, from distances of 50 to 100 feet. The acrobat is thrown up in the air a distance having a direct proportion to the distance he has fallen. It would be an interesting experiment to try a series of rope or wire nets, separated by, say, a foot or so apart, and drop weights, corresponding to bombs, upon them from different heights to see if a series of three or four nets would not stop the weights. If it were found that these nets were capable of stopping the weigths, then real bombs fitted with detonators could be tried to see if the bombs would detonate. If the experiments showed that they were successful, all gun emplacements of sufficient importance and other important elements of the defence might be protected from a direct hit by some such means as that suggested.

This proposition may appear absurd on the face of it, and it is not substantiated by any mathematical argument. Nevertheless, the fact remains that there is no case of which there is any record of bombs having fallen in accordance with the theoretical law of falling bodies, or in accordance with preconceived ideas. The very shape of the bomb, the fact that it has to pass through air strata of varying degrees of resistance, the fact that the thoeretical law itself may be wrong, certainly leave room for experimentation. Laws reduced by actual experience may safely be assumed to be correct, but who, before the invention of aeroplanes and actual bomb dropping, even had a chance to more than theorize in deducing a law for falling bodies?

The United States military authorities state positively that bomb dropping at altitudes of 6000 fee cannot be carried out with any degree of accuracy. As long as aerial raids can be kept at higher altitudes, they cannot be considered as a serious menace to fortified works. The question for the defence is, then, to provide means of keeping them at least 6000 feet up in the air.

The problem offered by the "spotters" is, however, a different one. They will climb sufficiently high and sufficiently far away from the guns, if possible, to be safe. If they are amply protected by destroyers and scouts, the question of their destruction does not

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seem to be a serious one. They must be accepted, under the conditions assumed, as a disagreeable factor to be reckoned with, and efforts will be made to keep them as far away as practicable. If they can be kept at 10,000 yards, then spotting will be exceedingly difficult for them; and, due to the film of smoke which will arise from the shore guns and any haze that may be over the ground, it may safely be assumed that if their spotting is to be of any value, they must be at least within 6000 feet of the striking points of the shells.

In order to determine upon the type of guns to be used in anti-aircraft defence, we have now to consider what will constitute effective hits on the air-craft of the various types discussed.

Shrapnel, or small arms fire, will only give effective hits when they strike the personnel, gasoline tanks, delicate parts of the motor, the propeller, and controlling parts of the mechanism. The Studevant people have constructed an all-steel battle aeroplane in which the motor, the controlling parts of the mechanism, the gasoline tanks, and the personnel are pretty well protected against such hits. Abroad they use calibres approximating 75 mm., and they use both shrapnel and high explosive shell with time fuses. These shell or shrapnel must make direct hits on the parts mentioned to wreck the machine.

The detonation of a medium-calibre, high-explosive shell within 100 feet of an aeroplane might cause the plane to dive or capsize, but would not necessarily wreck the machine. Aeroplanes have landed safely within their own limits with as many as 400 holes through the wings and fuselage.

The ordinary machine guns, such as the Benet, Lewis, etc., the latter of which is largely used abroad, do not use ammunition varying much from the ordinary ·30 calibre used in the Springfield small arms. The data available for the Springfield will therefore give us a standard of comparison. The maximum vertical range for small arms has been determined to be approximately 10,000 feet, and at 4000 feet the striking velocity is only some 900 feet per second. We may therefore rest assured that air-craft are fairly safe from machine gun or rifle fire at 4000 feet. They are effective at 6000, so we must have something more harmful to use in firing at them.

It is a well-known fact that the velocity of the air varies at the same place in different strata; and while in big gun practice, we assume a constant velocity and direction of the wind, it is only because the shell from a gun travels in the same stratum. As soon as mortars are involved the variations due to different strata through which the projectile passes introduce some curious results. It is impossible to deduce a rule, because the variation of strata in one day are different from those on another. However, these problems must be met, and are being met by the ballistician and mathematician, and several rules of thumb have been deduced for approximating the height of an airship. We assume, moreover, that the Ordnance Department has a reasonable range finder, and accurate setting device, when they announce that the "safe" elevation is at least 12,000 feet.

There is an advantage, also, to the defences in the fact that their aeroplanes are not burdened with drop bombs, can climb faster and out manœuvre the raiders who may be forced to drop their bombs

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prematurely in order to get away safely. Thus, if the defences still have a few air-craft left, they may be used very advantageously.

If the raiders succeed in getting well within the effective limit of bomb throwing, then they must be attacked with machine guns. They are liable to do so, and it is evident that the defences must have machine guns capable of being fired at any angle and from any position.

We must keep the scouts and destroyers at least 6500 feet away, if possible, and if they still continue to sweep down, to attack them with machine guns.

What means of attack by guns offers the best chance of success?

Evidently by directing a group of shots ahead of the target, calculating to create a dangerous zone through which the air-craft must fly.

The common analogy of shooting at a flying target will give us some idea of the arrangements to be adopted for the anti-aircraft guns One does not shoot at a flying duck with a rifle with any chance of success, but with a shot gun. The ideal gun to shoot at air-craft would be one having all the capabilities of the gun above described, i.e., the 3-inch, 15-pdr., but discharging a flock of shells from approximately the same place. Such a gun of medium calibre is not yet invented, nor does there appear to be hopes for one, but the distribution of the 15-pounders in such a way as to simulate this condition, is approaching the ideal. Experience has proven that the best unit is a four-gun battery, each gun at a corner of a 200-feet square and having a director in the centre.

The next condition is that these groups of batteries should be mutually supporting, again approximating the shot-gun idea. They should not be too close to the object to be defended, for three reasons: one of which is the danger of their being struck by a stray bomb directed at the battery they are defending; the second is, that as the air-craft approaches its object, the higher must be the elevation of the guns to hit the target, and the less accurate the fire; and the third is, that the smoke from the heavy guns will afford the aviator the means of spotting the anti-aircraft guns, and may lead him to attack them instead of the original object.

The guns, should, if practicable have an uninterrupted view of the horizon in all directions. The range finder and director being in the centre of the battery makes this nearly mandatory.

It should also be remembered that there will be no time for relocating against air-craft travelling 60 miles or more an hour.

A consideration of the above induces us to believe that the following should be controlling principles in locating the anti-aircraft emplacements containing the 3-inch (15-pdrs.) and the machine guns.

a. The most effective fire and fire control will be obtained by locating the guns in groups of four, each gun at the corner of a 200-foot square with the director at the centre.

b. To attack effectively, the hostile airplanes must be at an altitude of 6000 feet or less and approximately over the object being attacked.

c. The emplacements should be so located as to prevent hostile

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airplanes from reaching the position indicated in par. (b), *supra*, and should be able to bring a converging fire on any airplanes that are successful in attaining that position.

d. A single gun or group of guns defending any point, should be, when practicable, at least 1000 yards from that point.

e. The emplacements should be mutually supporting.

f. If practicable, the guns should have an uninterrupted view of the horizon in all directions.

g. Other considerations being equal, the emplacements should be located on government reservations.

h. Machine guns in groups of four or six should be located very close to the positions to be defended.

These anti-aircraft batteries should be controlled by an officer (director) stationed at the centre of the battery, assisted by the necessary enlisted personnel, and the batteries should be organized into higher units, composed of those batteries which are mutually supporting. As these batteries are designed to protect certain elements of the defences, the commander of the elements which they protect should also be the commander of the unit into which the groups are organized. The same general supervision exercised over the other elements of the defence by the coast defence commander, should be exercised by him over the anti-aircraft defences.

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A NOTE ON THE DEFLECTION FACTOR.

By Group Commander, R.G.A.

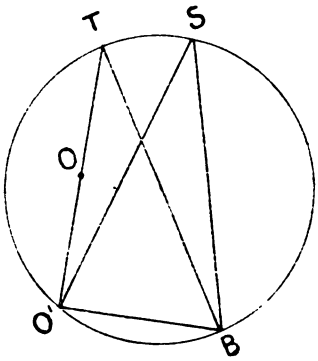
AN article appeared in the April number of the "R.A. Journal" on the Deflection Factor.

As the author states, the proportion $\frac{OT}{BT}$ gives increasing errors as the apex angle increases, when the observer is to a flank.

He suggests various remedies, but none seem so simple as a modification of $\frac{OT}{BT}$

Select on the map a point 0^1 on OT, produced if necessary, where TO^1B is at a right angle. If then the observation is converted by using the factor $\frac{OT}{O^1T}$ instead of $\frac{OT}{BT}$ the correct deflection correction will be arrived at.

PROOF.



When TO^1B is a right angle.
Then T, O^1, B, are all points of a circle whose diameter is BT.
"S," the fall of the shot, is so near to T in comparison to other dimensions that it may be considered as being also on the circumference of the same circle: Then TO^1S = TBS.

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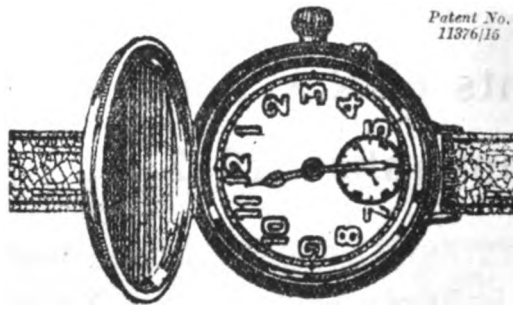

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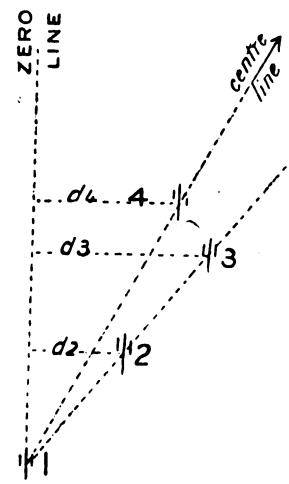
DISPLACEMENT TABLES FOR ECCENTRICALLY SITED BATTERY POSITIONS.

By Major W. H. Fry, M.C., R.G.A.

WITH the huge concentration of batteries now entailed, the placing of guns in eccentrically shaped positions becomes a necessity, and the resulting corrections in line and range, as measured from the standard gun, must be considered.

The following method permits of compiling tables from which the corrections can be quickly and accurately obtained.



The distance from the standard gun to each of the other guns is measured in yards, say D_2, D_3, D_4 yards respectively: and the dial sight of the standard gun is turned on to each of the other sights in turn, from the zero line reading, giving say $A_2°$, $A_3°$, $A_4°$, respectively

Then, when firing on the zero point, displacement for line is that equivalent to d_2, d_3, d_4 in turn (where $d_n = D_n \sin A_n$), its equivalent in minutes being $\frac{3438\, d_n}{R_n}$

The latter formula is easily solved by slide rule, by placing the range on B scale under 3438 on A scale, and reading m′ on the A scale over d yards on the B scale. This process is carried out for switches of every 10° right and left of zero line, through the arc of fire, at all ranges, the working being tabulated as follows:—

	No. 1	No. 2	No. 3	No. 4
Distance between guns	Nil	D_2	D_3	D_4
Angular displacement from zero line for switch S°	Nil	A_2-S	A_3-S	A_4-S
Perpendicular displacement from zero line for switch S°	Nil	d_2	d_3	d_4
Corresponding angular displacement at target	Nil	m_2	m_3	m_4

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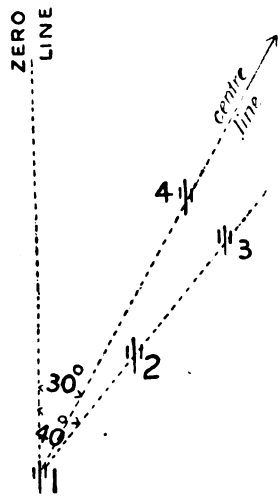
The range correction is given by $D_n \cos \overline{A_n\text{-}S}$ or $D_n \sin 90^\circ\text{-}\overline{A_n\text{-}S})$ which is read at once from the slide rule.

As an example, given that $D_2 = 50$ yards, $D_3 = 105$ yards, $D_4 = 132$ yards, $A_2 = A_3 = 40^\circ$, $A_4 = 30^\circ$, we have the following tables.

No. 2.	4000x	5000x	6000x	7000x	8000x	9000x	10000x	
30°L	40′	30′	25′	25′	20′	20′	15′	more L
20°L	35′	30′	25′	20′	20′	15′	15′	
10°L	35′	25′	20′	20′	15′	15′	15′	
zero	25′	20′	20′	15′	15′	10′	10′	
10°R	20′	15′	15′	10′	10′	10′	10′	
20°R	15′	10′	10′	10′	5′	5′	5′	
30°R	10′	5′	5′	5′	5′	5′	5′	
40°R	—	—	—	—	—	—	—	
50°R	10′	5′	5′	5′	5′	5′	5′	more R
60°R	15′	10′	10′	10′	5′	5′	5′	

Similarly for No. 3 and No. 4.



The displacement for range is given as under:—

	30°L	20°L	10°L	Zero	10°R	20°R	30°R	40°R	50°R	60°R
No. 2	−25	−30	−40	−45	−45	−50	−50	−50	−45	−45
No. 3	−50	−70	−80	−90	−100	−100	−100	−100	−100	−90
No. 4	−65	−85	−100	−115	−125	−130	−130	−130	−125	−110

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RESETTING RANGE DRUMS OF 18-pr. GUNS TO ACCOUNT FOR LOSS IN MUZZLE VELOCITY—A CRITICISM.

By Lieut. F. C. Higgins, C.F.A.

It appears to be not an uncommon practice among Battery Commanders in France to permanently *reset* the range drums of 18 pdr. guns in order to automatically account for errors in shooting due to loss of M.V. The end in view is of course the elimination of the trouble of having to apply a set of "gun corrections" at the different ranges. For example, if a gun was found to require a range of 3050 yards on the range drum in order (under normal atmospheric conditions) to hit a target the correct map range to which was only 3000 yards, the range drum would then be *reset* so that for the same elevation of the gun necessary to hit the target the range drum would be reading the correct map range of 3000 yards, instead of as before 3050 yards. The gun would then be shooting "map range," as we call it, and it is assumed therefore that no further corrections to range need be made even when shooting at other ranges. There are those, of course, who will admit that probably certain errors are introduced by this practice when shooting at other ranges than that at which the range drums were readjusted, but they argue that these errors are not likely to be serious enough not to justify its use.

On the contrary, however, I shall endeavour to show how erroneous an impression this really is and by means of examples to show how serious the errors incurred by the practice are certain to be. Furthermore, it will be found to be not only a question of errors in *range* that we must take into account, but also of the correct *fuze length*, for the latter will not be the same under conditions imposed by this practice as would normally obtain, and this is probably quite as important a point as the error in range. For the sake of simplicity the examples are to be considered as obtaining under normal atmospheric conditions when no weather corrections are necessary. This, however, will in no wise detract from the value or fairness of the examples.

Let us consider the case of a battery in which the guns have been carefully calibrated and found to be shooting *short* at 3000 yards, by 25, 50, 75, 100, 125 and 150 yards, respectively for the six guns. This is an average condition for a battery under the conditions of warfare on the Western Front, and is equivalent to M.V.'s respectively of 12, 23, 35, 46, 58 and 70 f.s. below 1615. If now range drums are altered to offset the above errors in order to make the guns shoot map range at 3000 yards, the increase in angle of

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elevation thus effected in each case would be 3·5, 7, 10·5, 14, 17·5 and 21 mins. Let us now see what the character of the shooting would be at the various ranges.

AT 3000 YARDS.

It is obvious that at this particular range there will be no error at all in the range for the simple reason that the angle of elevation has been altered exactly to counteract the loss in M.V. in the case of each gun. But let us stop to consider the effect on the correct fuze length. The error incurred in the latter will always depend solely upon the difference in *time of flight* brought about by the loss in M.V. of the gun which causes the shell to fall short of the actual map range appearing on the range dial (for which the fuze is determined) and hence produces a shorter time of flight. But it is very unlikely that this difference in time of flight due to loss in M.V. is as great as would result if it were a case simply of a difference in angle of elevation of the gun which would cause the shell to fall short of the target by the same amount. On this point it is generally considered by those who have had the opportunity of conducting fairly exhaustive tests that the difference in time of flight due to errors incurred by loss in M.V. is about *one half* of that due simply to a difference in angle of elevation of the gun which would cause the same extent of error. But under the conditions we are examining, the fact that the range drums have been altered from their normal setting, thus changing the angle of elevation, imposes certain complications the effect of which must be taken into account.

Let us apply this principle to the case in question at 3000 yards, and determine what the actual effect would be on the correct fuze length. The first two guns have not a sufficient error to make much difference, but take the case of the third gun with an error equivalent to 75 yards. The time of flight for which the fuze will be determined will of course be that for a range of 3000 yards, which is the range appearing on the range dial. The increase in angle of elevation equivalent to an increase in range of 75 yards will increase the time of flight by ·22 seconds. But the loss in M.V. causing the shell to fall 75 yards short of the range equivalent to the total angle of elevation on the gun will decrease the time of flight by ·11 seconds. Hence, by subtracting ·11 seconds from ·22 seconds we obtain the resultant *increase* of ·11 seconds in time of flight over that for which the fuze was determined (i.e. for 3000 yards.) This means that the fuze length as used will be about ·1 too short for this particular gun, and similarly in the case of the last three guns the errors will be respectively about ·15, ·2 and ·25 on the fuze. Hence, four guns out of the six will be firing time shrapnel with an average mean point of burst for the four guns almost *20 mins.* above the line of sight, which is quite a serious

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error indeed and represents a needed lengthening of the corrector by an average of about 6 divisions to bring the centre of the bursts down to the correct height of 10 mins. This is presuming that no allowance has previously been made in the corrector for the loss in M.V. of each gun—as would have been done under ordinary circumstances when applying gun corrections and corrector changes in the ordinary way. If, however, this practice of applying corrections to the corrector for loss in M.V. is still continued, the errors will be *twice* as great.

It might be stated that at 2500 yards (which is a range very often required of 18-pr. guns) a similar condition will obtain to what we have found at 3000 yards as regards errors in the fuze, only the errors here will be proportionately *greater*, contrary to what might be expected. On the other hand the errors in range will average less than 25 yards and are therefore not very important.

Let us now consider what conditions we would expect to find with the same guns at ranges of 4000 yards and 5000 yards, the latter being about the limit of useful range for the 18-pr. Obviously there are two factors to be considered, the *resultant* effect of which must be determined—(1) the M.V. of each gun which produces greater errors as the range increases, and (2) the alteration made in the angle of elevation when resetting the range dials, which produces less effect on the range as the latter increases and hence steadily loses its initial corrective value on the range. Curiously enough it will be found that whereas on the one hand the resultant errors in range will increase as the range increases, on the other hand the errors in the proper fuze length will be much greater at the shorter, and *more important*, ranges.

AT 4000 YARDS.

The M.V.'s of the respective guns would cause them to shoot short at 4000 yards by 30, 58, 87, 116, 145 and 175 yards. The increase in angle of elevation due to altered range drums would cause them to shoot over by 21, 42, 63, 84, 105 and 126 yards. Now the difference between these two sets of figures will give a resultant shooting *short* of

9, 16, 24, 32, 40 and 49 yards.

This means that out of the six guns, the second pair will have an error of about 25 yards, while the last two an error of approximately 50 yards. Hence only the first two guns can be said to have kept even a fair degree of accuracy.

In regard to the effect upon the proper length of fuze to be used, it will be found that in the case of the two guns showing an average introduced error of 25 yards, the fuze length as determined from the actual range appearing on the dial strip will be approximately ·06 too short, which, of course, is not important because we cannot change the fuze by less than ·1. But for the two guns with an error of approximately 50 yards the length of fuze will be somewhat more than ·1 too short. This latter is quite an appreciable error in the point for effective burst and represents a needed lengthening of the corrector by at least 2 divisions at this

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range. It is equivalent to lowering the mean point of burst by more than 5 mins. down to the correct angle of 10 mins. above the line of sight. Let us see now what we might expect at 5000 yards.

AT 5000 YARDS.

The respective M.V.'s would cause the guns at this range to shoot short respectively by 33, 64, 95, 126, 157 and 188 yards. The increase in the angle of elevation due to altered range drums would cause them at 5000 yards to shoot over by 18, 36, 55, 73, 91 and 109 yards. The difference between these two groups of figures will give a resultant shooting *short* of

15, 28, 40, 53, 66 and 79 yards,

which means that the second gun has an error of over 25 yards, the next two of over 50 yards, and the last pair about 75 yards. Hence in this case there remains only one gun, the first, which has not incurred quite a serious error.

With regard, however, to the effect on the correct fuze setting, strange as it may seem, the errors incurred at this range are practically negligible for it appears that the factors involved more or less counteract each other.

Now if these figures which we have found to obtain under the above conditions at ranges from 2500 yards to 5000 yards be compared with a similar set of figures worked out for the same guns at the same ranges, but under conditions in which instead of altering the range dials, a set of gun corrections and corrector changes for the various ranges and guns are automatically made by the Nos. 1 in the ordinary way, we would find the surprising contrast that the errors in the latter case would in no case at any of the ranges be greater than 12½ yards in the range, and there would be no error in at all in the length of fuze. Even if only one *mean* correction to the range and corrector be made for all ranges, the errors would still never exceed 25 yards, and there would again be practically no error in the length of fuze. And certainly the making of only one mean correction for all ranges by the Nos. 1 can hardly be said to incur any appreciable loss of time or accuracy as compared with the method of changing the range drums, which latter of course does away with any corrections by Nos.1 .

However, if in the latter case it should really be desired, in addition to changing the range drums, to make gun corrections and corrector changes in order to overcome these errors, we would at once be confronted with a most difficult task, for it would be quite impossible to rely any longer upon the ordinary method for determining what these corrections should be, since it has already been pointed out that in so doing the already existing errors would very likely be *doubled* in many cases. In fact it would be found neces-

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sary in order to determine the right corrections at the different ranges to employ an entirely new and different basis for calculation than that ordinarily used when dealing with M.V. pure and simple. Hence, this would only serve to increase very largely the difficulties concerned by introducing more complicated methods of calculation with consequent greater chances for error in same, and in the end with a net result really *less satisfactory* from every point of view, be it time, accuracy or labour, than if the ordinary procedure were followed in which the gun errors and wrong corrector settings due to loss in M.V. are automatically allowed for by corrections made by Nos. 1.

We have seen, it is true, that at *one* particular range, namely that at which the range drums are readjusted, there will be no error at all in the range, but at the same time it was evident there would be quite a serious error in the length of fuze, which is a point probably of equal importance. However, at *all other* ranges there are bound to occur very considerable errors in both the range and length of fuze, as the examples have clearly shown, and when we consider that in almost all of our offensive operations on the Western Front the programs for barrage fire call for a continuous lengthening of the range from say 2500 yards, to well beyond 4000 yards, the seriousness of such errors must at once become apparent. The time has passed when a Battery Commander, in the days when there was no offensive and trench warfare was at a standstill, could feel that the only range he need be particular about was that with which he protected his own front line, which, of course, was invariably about 3000 yards.

It is possible that some may suggest that if a range of 4000 yards is selected at which to readjust the range drums instead of 3000 yards, the *average* error incurred at ranges between 3000 yards and 5000 yards will be reduced to such a minimum as to still justify the practice. But, as a matter of fact, the figures in such a case go to prove that at 3000 yards for instance, which is generally the most important range of any at which to avoid errors if possible, the error in range would be actually *greater* (and opposite in character—i.e., plus instead of minus) than would obtain at 4000 yards in the original case. It is true that the error at 5000 yards would be somewhat less than in the original case, and of the same minus character, but this *by no means* offsets the actual increase in error at the very important range of 3000 yards, at which, admittedly, the majority of the shooting will take place in the ordinary course of events. And with regard to the fuze, the same condition applies except that in this case the increase in error at the shorter ranges will be still more apparent and seemingly out of all proportion to what might be expected.

It is evident, therefore, that from every point of view one is forced to condemn this practice of resetting range drums, not only because it has no real advantage even where it is claimed it should have its greatest asset, that is, in the elimination of all necessity for corrections for M.V., whether by Nos. 1 or by the Battery Com-

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mander, but it must also be condemned because it actually introduces much greater errors, as we have shown, than even the most inaccurate method of applying corrections in the ordinary way. The latter, of course, is to make one *mean* correction for range and one for the corrector for each gun for all ranges.

In concluding, it may be of interest, while this question of accounting for errors due to loss in M.V. is before us, to add that there are those who suggest as the best solution of the problem the use of a novel method involving an alteration in the *angle of sight* according to a definite rule depending upon the M.V. of the gun and the range to the target. The advantage claimed, is that of accomplishing in the *one* operation both the necessary correction to the range, and at the same time the elimination of the error in the length of fuze. Admittedly, if this were actually the case there would certainly be much to commend in the method, but unfortunately the claim seems to be based upon a very wrong assumption. It is quite true that the method will accurately account for the errors in range, but not so with regard to the fuze—and for this reason, which has already been touched upon, that the difference in time of flight due to a difference in angle of elevation is *not* the same as that resulting from an equivalent difference in M.V. measured in yards.

Here is the whole point of the question, and it leads us to conclude that in this case, as in the resetting of the range drums, the method will fail to accomplish the results which were expected of it. After all, we will probably find in the end that the safest and best methods to follow in all such cases will be those laid down by the *authorities* on the subject, who are best able to judge, and whose suggestions are embodied from time to time in the official circulars that are issued to all concerned—hence a moral!

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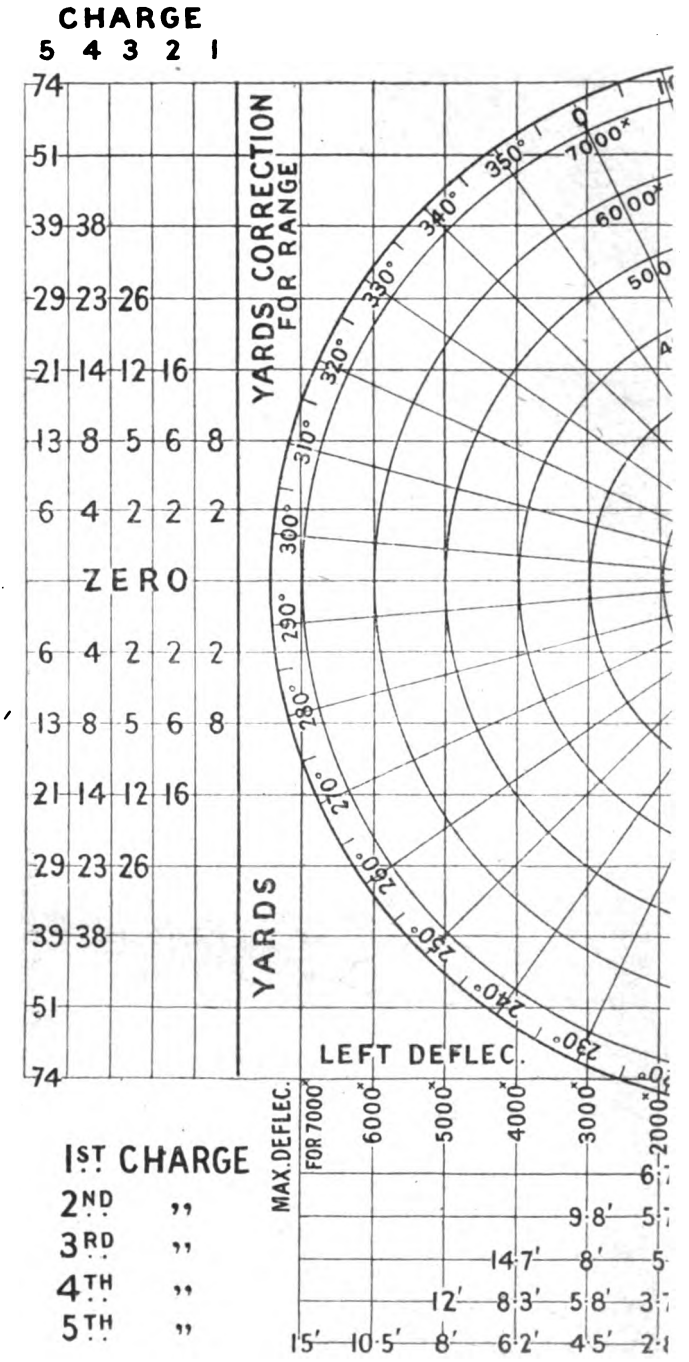
WIND 10 f.s.



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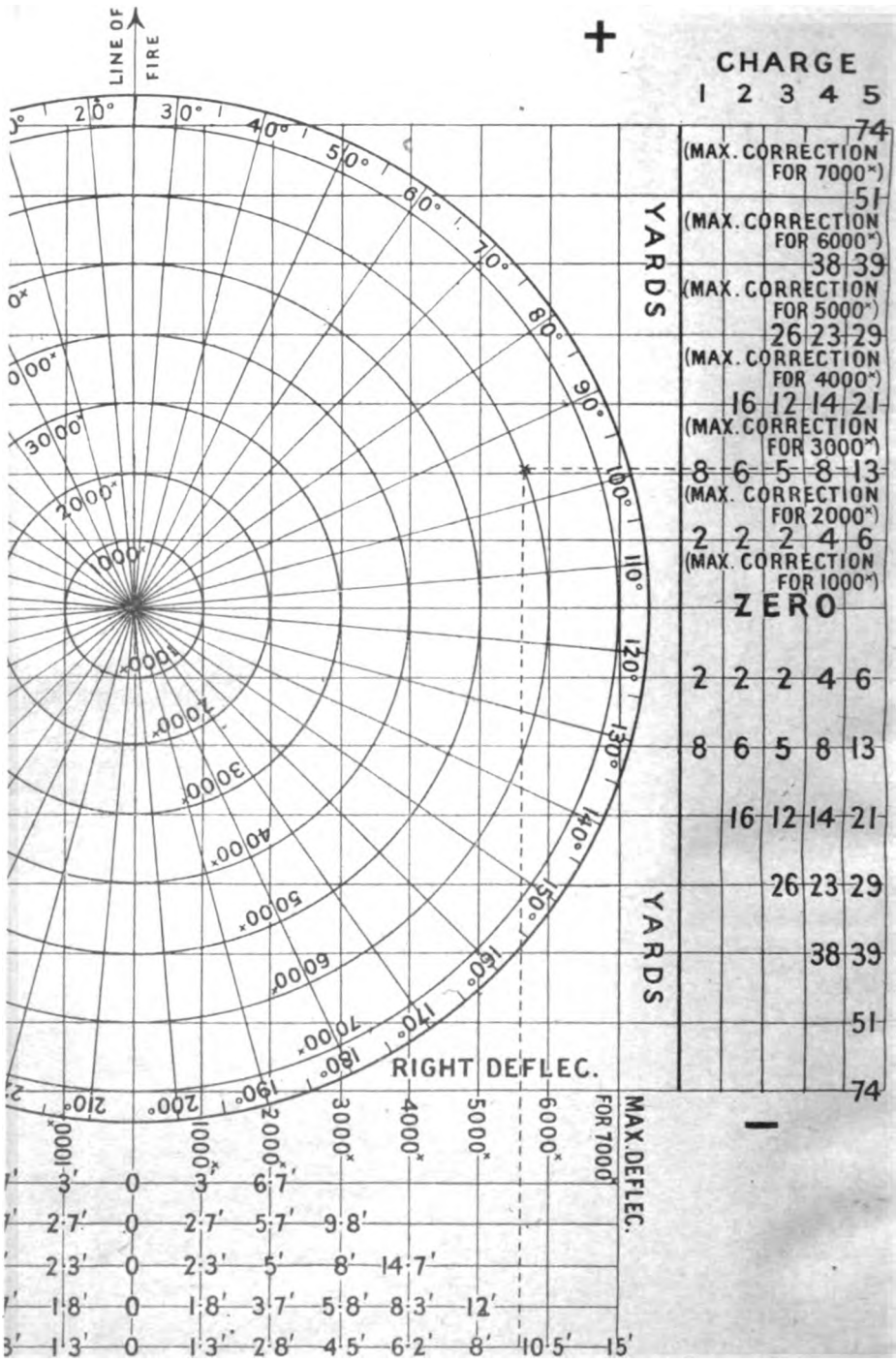

ND DIAL
4·5" HOW.

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WIND DIAL FOR 4·5″ HOWITZER.

By 2nd Lieut. W. L. Dennis, R.F.A.

THE Wind Dial as shown by the accompanying diagram may be found of use when making wind corrections (range and deflection) for the 4·5″ Howitzer. It is simple in construction and use and requires no reference to Tables. The Dial which is made of celluloid is pivoted at its centre and mounted on a xylonite plate. It shows corrections for a 10 f.s. wind.

To use the Dial.

Set the Dial so that the true bearing of the target coincides with "Line of Fire" indicated by the arrow at the top. Note the particular radial line representing the true bearing of the wind, and the point in that line where the range circle cuts it. Read off horizontally from the Table at the side the wind correction in yards, plus or minus, for the given range and charge, and, vertically, the deflection in minutes right or left.

In reading the Table to correct for range note the maximum correction for the given range and charge. Next determine the ratio of the distance "on the plate" between the horizontal reading and "zero" and the maximum correction for the given range and charge and "zero". This ratio of the maximum correction gives the required correction for range.

To correct for "line" determine the ratio of the distance "on the plate" between the vertical reading and "O" and the maximum correction for "line" for the given range and charge and "O". This ratio of the maximum correction gives the required correction for "line".

Example—

True Bearing of Target	25°
Wind	95°
Velocity of Wind	20 f.s.
5th Charge.	
Range 6000ᵡ.	

Set Dial so that 25° coincides with "Line of Fire" (see diagram). The horizontal reading for 95°, 5th charge and 6000ᵡ range is at a point such that its distance from "zero" = ⅓ of the distance between the maximum wind correction for 5th charge and 6000ᵡ range (i.e. + 51ᵡ) and "zero"

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Correction for range with 10 f.s. wind $= \frac{1}{3} \times 51^{\text{ᵡ}}$
$= + 17^{\text{ᵡ}}$
20 f.s. $= 2 \times 17^{\text{ᵡ}}$
$= + 34^{\text{ᵡ}}$

The vertical reading for 95°, 5th charge and 6000ᵡ range is at a point such that its distance from "O" $= \frac{11}{12}$ of the distance between the maximum wind correction for 5th charge and 6000ᵡ range (i.e. 10·5′ R) and "O".

Correction for "line" with 10 f.s. wind $= \frac{11}{12} \times 10{\cdot}5'$
$= 9{\cdot}6'$ R.
20 f.s. $= 2 \times 9{\cdot}6'$
$= 19{\cdot}2'$ R.

NOTE.—The corrections given for Range are taken from "Range Tables for 4·5″ Q.F. Field Howitzer" bearing No. 40/W.O./3251. A new Range Table for the 4·5″ Q.F. How. bearing No. 40/W.O./3705 has recently been issued. The corrections for Range given in the new Range Table should replace those given in the Wind Dial.

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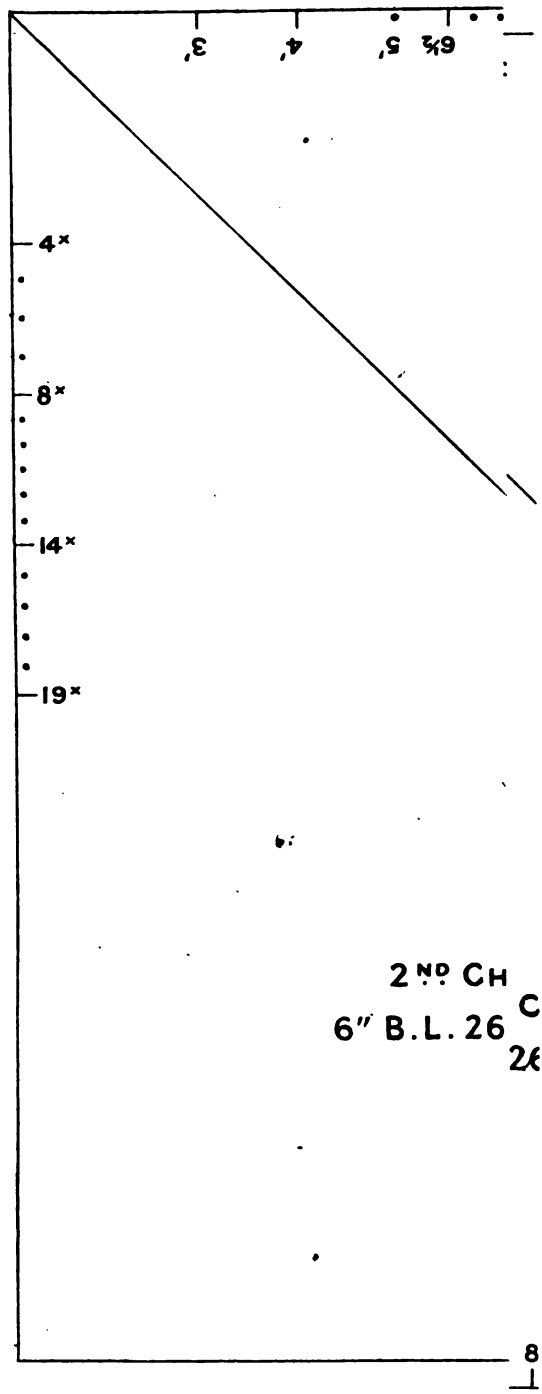

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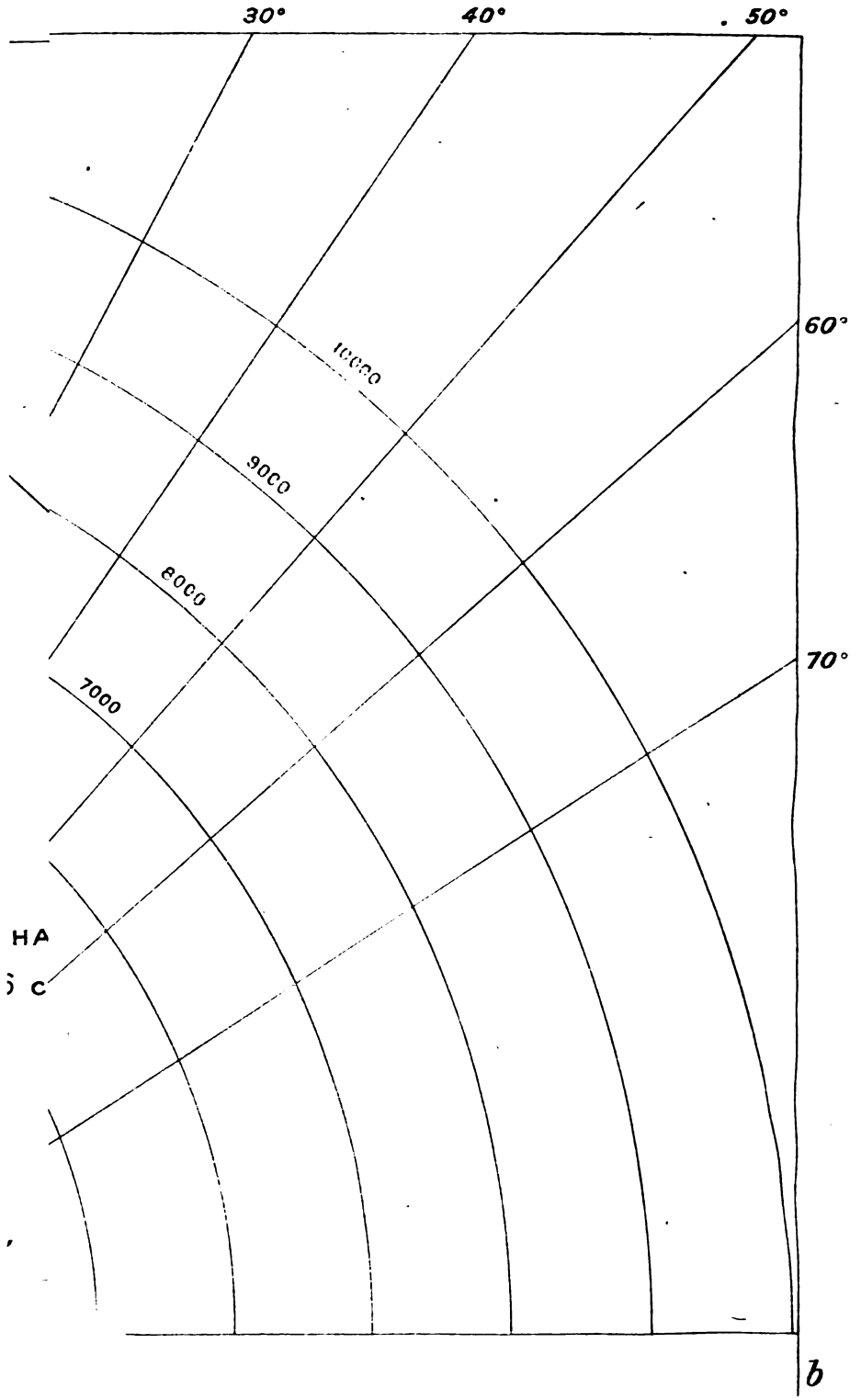

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WIND GRAPH FOR USE WITH HOWITZERS.

By Major C. B. Down, R.A.

THE graph has been designed with a view to shortening the time required to work out corrections for wind.

As the corrections for different angles of wind do not alter in a geometrical progression, it stands to reason that straight lines for rays cannot give entirely accurate results, but the results are in no case inaccurate by more than a small proportion of the 50 % zones of the gun at any range.

The corrections are given for a 10 fs. wind, and it may be argued that for high velocities of wind, corrections will become too inaccurate to use. But it must be remembered that corrections for high wind velocities are not of much practical value, the shell being blown about in a very irregular way.

The illustration gives a sample graph for the 6 in. 26 cwt. How.

The rays have been plotted from actual slide-rule results.

To read. Place the corner of the card for the particular charge at the intersection of angle of wind and BT range. (The sides of the two cards should be kept as parallel as possible.)

Against line A read the correction to range in yards, and against line B read deflection in minutes. For 10 fs.

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ACCURACY OF FIRE AND THE QUESTION OF SMALL CORRECTIONS FOR LINE AND RANGE,

By Captain W. M. Roberts, R.G.A.

THIS note is intended to give figures showing what percentage of of rounds are really effective in trench-shooting and also to show that in certain cases small alterations in elevation and line are justifiable. I have never seen any calculations which really covered the actual facts in shooting, although I have often heard misleading statements as to the small number of effective hits to be expected according to the theory. The results given are so depressing that they usually give the firm conviction to one who has not made the calculations himself (especially if he has had much practical experience of trench shooting) that the theory on which the calculations depend is all wrong, whereas the reverse is the case. There are few theories which square so well with the facts as that on which the calculations made here are based.

The mistake usually made in these calculations is to treat the projectile as a particle which the gunner is trying to land between two lines two or three feet apart. But in fact a 5·9″ shell landing two yards from a well revetted trench will throw up some of the timber and plainly show the observer that the trench has been damaged. Therefore, if such a trench were dug one yard wide, for the purposes of the calculations it can be spoken of as having an "effective width" of five yards i.e. 2 yards each side plus the width of the actual trench. A round heavy enough to blow in the trench 3 yards away would make the effective width 7 yards. It all depends on the character of the soil and the size of the shell.

Taking 50 per cent. zones of various widths of 20 yards and above the following tables give the percentages of rounds which could be counted as hits on trenches with effective widths of 5, 7 and 9 yards; these percentages are calculated from ordinary Table of Probability Factors.

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Table I.

Length of 50% zone.	Distance of M.P.I. from centre line of trench.	FRONTAL FIRE. Percentage of effective rounds on trenches of width 5 yds.	7 yds.	9 yds.
	0	13·5%	18·5%	24%
	5	12·5	17·7	22·7
20 yards	10	10·7	14·8	19
	15	8	11·3	14·3
	20	5·5	7·7	10
	0	9	12 7	16
	10	8	11·3	14·6
30 yards	15	7·2	10 1	13
	20	5·8	8·3	10·6
	30	3·8	5·	6·6
	0	6·7	9·5	12·2
	10	6·5	9·	11·2
40 yards	20	5·4	7·5	9·7
	30	4·0	5·6	7·2
	40	2·8	4	4·9
	0	5·5	7·5	10
	10	5·2	7·2	9·2
	20	4·7	6·5	8·2
50 yards	25	4·4	6·	7·7
	30	3·8	5·3	6·8
	40	3·	4 4	5·5
	50	2·2	3·1	4·
	0	3·7	5·2	6·5
75 yards	25	3·1	4·5	5·7
	37½	2·9	4·1	5·1
	75	1·5	2·0	2·6

Table II.

		ENFILADE FIRE.	
	0	74	88
3 yards	5	13	25
	10	nil	nil
	0	60	76
4 yards	5	19	31
	10	nil	1·6
	0	50	65
5 yards	5	23	33
	10	2	4
	0	43	57
6 yards	5	24	34
	10	4·6	7
	0	26·5	36
10 yards	5	21	29·5
	10	11	15·5
	15	3·5	5·4

There is no real difference between the two tables, the results in either table are correct for either enfilade fire or frontal fire, they are merely put separate for convenience.

Looking at Table I it will be seen that in all the cases given, if the range is out by half the 50% zone, the alteration in the proper direction of the M.P.I. by that amount will improve the effect of the shooting by about one quarter—a result worth striving for.

In enfilade at 6000 yards, an error of 5 yards in line is just under 3 minutes. A correction of this amount would very much

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improve the shooting as a glance at the table will show; a correction of 5 minutes would only slightly improve things. It is therefore clear that in shooting a gun which is really good for line with good observation corrections of less than 5 minutes are worth while. This is one of the cases where a correct line is more important than a correct range, as is so often the case.

Another interesting result which can be deduced from calculations on the effective width of trenches is that if the M.P.I. is out by half the 50% zone—let us say short—then leaving out rounds which are observed as hits (i.e. those that clearly remove trench material) the proportion of minus to plus rounds is about 3 to 1. A more equal proportion shows the M.P.I. is within half the 50% of the centre of the trench.

A consideration of 50% zones with an accurate gun at lower ranges will show that there are cases where it will pay even to split 5 minutes of elevation, since the 50% zone may approximate to 5 minutes in such cases. It will certainly pay to split 5 minutes of deflection in enfilade fire. On the other hand with large 50% zones near the end of a range table the effect of 5′ or even 10′ alteration will be seen to give an almost negligible improvement in the shooting.

In the case of oblique fire, the results in the tables will hold except that the effective width of the trench is

$$\frac{\text{width for frontal fire}}{\text{cosine of angle of deviation from frontal fire.}}$$

e.g. if the effective width is 5 yards, and the line of fire is 45° away from the direction for frontal fire, the results for a trench width $\frac{5}{\cos 45^\circ}$ i.e. 7 yards would apply pretty nearly to this case. If the angle were 20°, the result would be to widen the trench from 5 to $\frac{5}{\cos 20^\circ}$ = 5·3 yards.

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A NOTE ON THE GRAPHIC REPRESENTATION OF FORMULÆ USED IN THE ARTILLERY VERSUS THE SLIDE RULE.

MAJOR J. MAITLAND-ADDISON, R.G.A., *pac.*

THE Slide Rule—handy instrument as it is—as a means of solving formulæ—has its limitations, when used in the theatre of war. Its disadvantages are:—

i. It is necessary to remember the formula in question or to have it written down in a notebook conveniently to hand before it can be made use of to solve any particular case.

ii. It is easy to make a mistake when using it—particularly in fixing the decimal point.

iii. There are many officers who never could and never will be able to use it efficiently.

For this reason I would call attention to the value of suitable graphic representation of such formulæ as are required in the Artillery—in this case especially in the Siege Artillery.

Graphic methods of solution are to be preferred for the following reasons:—

i. There is no necessity to remember or even know the formula.

ii. Provided that suitable means of graphically representing the formula are made use of, anyone can learn to use the graph accurately in a few minutes.

iii. It is more difficult to make a mistake when using a graph than when using a slide rule.

iv. Mental labour is greatly economized, a consideration not to be lightly estimated in the field.

Take as an example the now well known factors D/O and E/O used in the Siege Artillery. Fig. (1) illustrates the first of these two factors fully represented graphically on five parallel straight lines. The formula is

$$\frac{D}{O} = \frac{r}{R \cos \theta}$$

in which

r is the Observer's range.
R,—the Battery range.
θ,—the Apex angle.

The method of using this diagram is very simple. Let r = 1000 yards, R = 5000 yards, $\theta = 30^\circ$. Place a straight-edge across Scales A and D at 1000 yards and 5000 yards respectively, crossing Scale B at ·2. Now place the straight-edge at this point on Scale B and at 30° on Scale E. The required value of D/O is the point where the straight-edge crosses Scale C.—i.e. at ·23. A pencil makes a suitable straight-edge—or after a few minutes practce, the required value of D/O can be obtained by eye.

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As the Scale E would be infinitely long for an apex angle of 90°, the graph at once shews that there is no value of D/O for such an apex angle except infinity. It further illustrates the objection to using this factor except for small apex angles, since the value of D for any given observation O becomes so large.

Similarly Fig 2 illustrates on five parallel straight lines the factor E/O, the formula for which is

$$\frac{E}{O} = \frac{r}{688 \text{ Sin } \theta \Delta R}$$

which can also be written as

$$\frac{E}{O} = \frac{r}{\text{Sin } \theta} \quad \frac{5}{3438, \Delta R}$$

in which

r is the observer's range in yards.

θ,—the Apex angle.

ΔR,—the number of yards of range equivalent to 5′ change in elevation.

3438,—the well known range finding constant.

These two diagrams can be conveniently printed on one side of a piece of good ivory board of a size suitable for the pocket, or photographed on good photographic paper, or on xylonite.

They can also be conveniently carried in a loose leaf pocket book.

Fig. 3 shews also a graph for determining at a glance the "concentration" necessary for any range and any angle of switch from the zero line for converging guns from parallel lines of fire on to a point.

It is designed for a displacement of 100 yards, so as to reduce the number of lines on the graph to three, which makes it simpler to use.

All displacements of guns from the pivot gun can always be arranged for as convenient multiples of 100 yards—i.e. 20 yards, 25 yards, 100 yards, 200 yards, etc., etc.

Thus if the displacement is 125 yards, and the switch angle 40° —range 6000 yards, the necessary concentration is 5/4ths of 45′ = 55′, and so on. One point there is in the use of such graphs, which might by some, be considered to be a disadvantage—that is that a separate graph is required for each formula, whereas the slide rule will solve most formulæ.

My experience is that in view of the few formulæ required to be made use of at any one time or place, this disadvantage is negligible. It is immaterial to those using such graphs as to how they are constructed. It will suffice to add that should any officer be interested in the subject, reference can be made to Monsieur d'Ocagne's, "Nomographic," a fine treatise in French—or to Lieut.-Colonel R. K. Hezlets' excellent pamphlet, obtainable from the R.A. Institution, Woolwich, and to other books. There is undoubtedly a large field for the construction and use of this modern graphical representation of formulæ both in the Services and in civil life.

The writer of this article wishes to point out that he had no knowledge until about four months ago, that there was in existence an official card illustrating the D/O and E/O factors—on somewhat similar lines—nor had he ever seen it until quite recently. His own card on the line shewn above, was designed in June 1916, but was used by himself only, and not put forward until this year. His object in having written this article is to emphasize the value of such graphic treatment, as the subject is still not well known.

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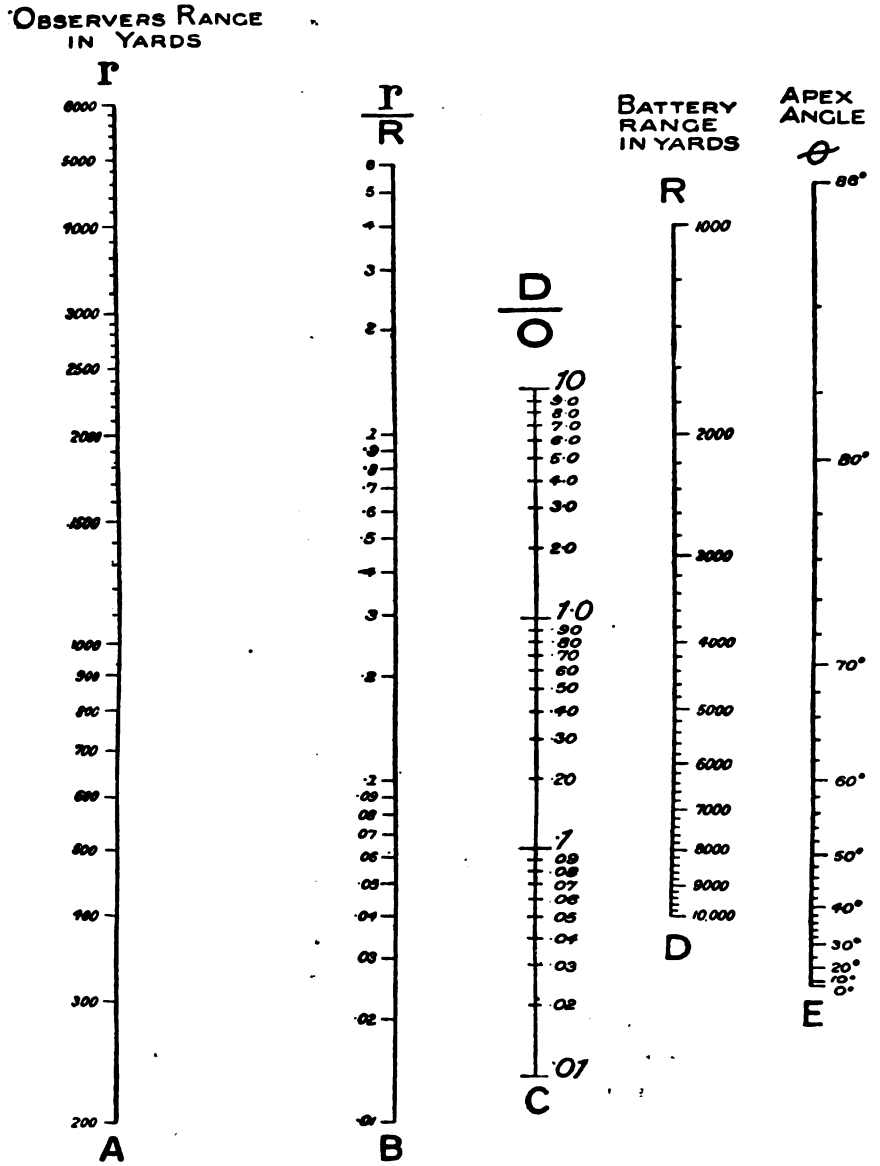
DEFLECTION FACTOR

FOR RANGING ON LINE OT.

$$\frac{D}{O} = \frac{r}{R.\cos.\theta}$$



EXAMPLE OF HOW TO USE THE DIAGRAM

OBSERVERS RANGE = 800 YDS.
BATTERY RANGE = 4000 YDS.
APEX ANGLE = 30°

PLACE A STRAIGHT-EDGE ON SCALES A AND D AT 800' AND 4000' RESPECTIVELY. NOTE READING ON SCALE B. PLACE STRAIGHT-EDGE ON SCALE B AT THIS READING AND AT 30° ON SCALE E, THE READING ON SCALE C IS THE REQD. $\frac{D}{O}$ = ·23 = ¼ APP

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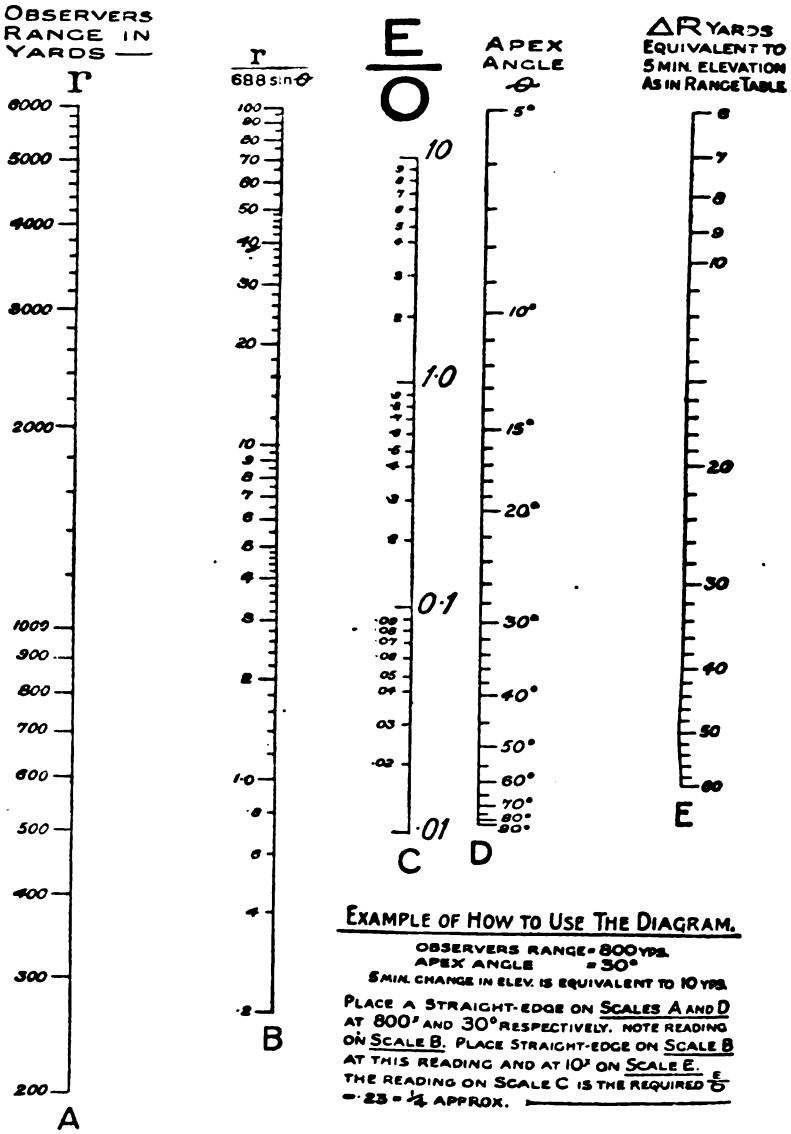
ELEVATION FACTOR

FOR RANGING ON LINE OT

$$\frac{E}{O} = \frac{r}{688 \sin\theta \Delta R}$$



EXAMPLE OF HOW TO USE THE DIAGRAM.

OBSERVERS RANGE = 800 YDS.
APEX ANGLE = 30°
5 MIN. CHANGE IN ELEV. IS EQUIVALENT TO 10 YDS.

PLACE A STRAIGHT-EDGE ON SCALES A AND D AT 800' AND 30° RESPECTIVELY. NOTE READING ON SCALE B. PLACE STRAIGHT-EDGE ON SCALE B AT THIS READING AND AT 10' ON SCALE E. THE READING ON SCALE C IS THE REQUIRED $\frac{E}{O}$ = ·23 = ¼ APPROX.

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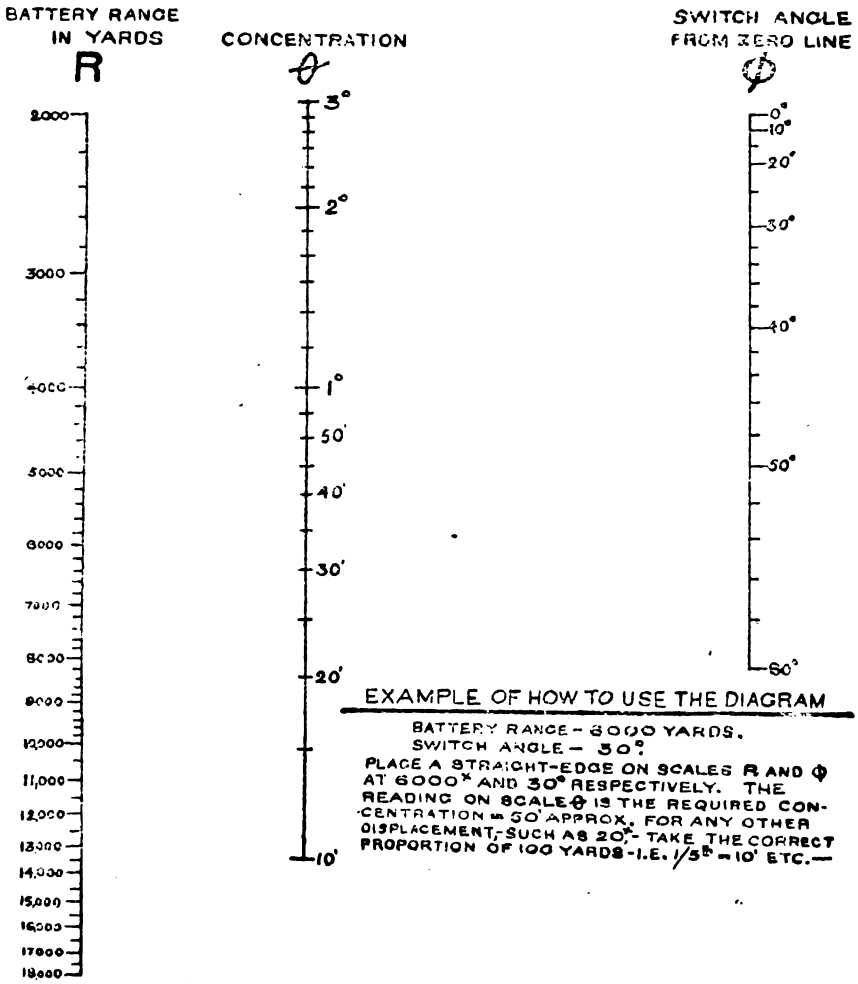

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PRÈCIS OF
MEMORIAL DE ARTILLERIA.

BY MAJOR R. H. R. BENSON, R.A.

May, 1917.

A short article insisting on the supreme importance of Artillery in modern warfare—by sea and by land—leading up to a call for the reorganisation of the Spanish Artillery.

Coast Defence.

The war has shown that heavy guns and abundant ammunition are essential to success, whether in the field, at sea or in coast defence. Modern battleships are powerful offensive units and carry many heavy guns and plenty of ammunition. Coast defence batteries must therefore be put on a level with battleships, both as to number of guns, calibre and protection. The movable armament of a coast Fortress is merely auxiliary and cannot in any way replace the primary fixed armament. Distant bombardment of Naval Bases will be more often undertaken than formerly since the range of modern naval guns renders this possible, and coast defences must therefore be armed with powerful long range weapons wherewith to combat such attacks. There is no reason, at present, to suppose that coast defences can be done away with and submarines depended upon to protect coasts and harbours. The co-operation of aircraft with coast defence batteries is essential.

Artillery Aviation.

An article on the special work of aviators in connection with artillery; (a) reconnaissance of enemy battery positions, and other targets and (b) observation of fire.

For efficiency it is essential that special aeroplanes be told off to the artillery and be under the orders of the G.O.C.R.A. of the Group or Division: such aeroplanes to be reserved for artillery work only, and to be protected, if necessary, by battle-planes provided by Army Headquarters. The artillery aeroplane should if possible be manned by trained gunner officers: at any rate the observer should be a gunner, and the pilot should be subordinate to him. Preliminary training with R.A. Brigades most necessary; so much so that no

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practice should ever be carried out without participation of artillery aeroplanes.

The writer also claims that bombing aeroplanes should have gunner pilots, the dropping of bombs being essentially a ballistic problem.

June, 1917.

The action of the Allied Fleets against the Dardanelles.

An account compiled from the published English and French reports. It is noted that no Turkish or German reports have been published, and it is therefore not possible to draw any definite conclusions. A general description of the topography of the Dardanelles is given, with two maps taken from "*The Times*", and an outline of the defence works and their armament. Points out that there is reason to doubt whether any 14·25 guns were actually mounted, though many accounts state that 6 of these were mounted in the batteries defending the Narrows. A list of the ships composing the attacking forces, and their armament is given. Then follows an account of the various bombardments carried out between 19th Feb. and 18th March, the date of the great general attack on the Forts of the Narrows.

In the absence of information as to the damage done to the Forts by this bombardment it is not possible to say how far it was successful nor whether it could with advantage have been followed up, but in view of the damage to the attacking ships by gun fire, of the loss of three battleships from drifting mines, of the fact that at sunset on the 18th most of the Turkish batteries were still in action, the writer concludes that the attack failed, and this conclusion is borne out by the fact that the attack was not renewed. The arrival in these waters of German submarines shortly afterwards led to the withdrawal of the more important units of the attacking squadrons and to their replacement by monitors.

The only general conclusion which can be drawn is that Coast Defence guns enjoy so many advantages over ships guns that only an enormous disproportion in numbers and calibre in favour of the attacking squadron can give it any hope of success, and that if the guns of the defence are supported by mines and submarines and by movable armament guns the task of the attacking force becomes well nigh hopeless.

Miscellanea.

Some notes on the U.S.A. 16-inch guns for the Panama Canal defences. This is said to be mounted on a disappearing mounting. The gun weighs 154 tons, fires a 2400 lb projectile with M.V. 2700 f.s.

Some notes on the Davis non-recoil gun for aeroplanes (taken from 'Scientific American'). This gun has its chamber in the middle, the barrel being rifled in front of the chamber but smooth bore behind.

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The ammunition which is 'fixed' consists of a brass cartridge case cylindrical in form with the shell inserted at one end and a charge of dust shot at the other. When the gun is fired the dust shot is fired out backwards and consequently there is no recoil of the gun itself. The gun has been tried in various sizes from 2-pdr. to 12-pdr., and is stated to have been very successful. The M.V. is about 1100 f.s.

Notes on the Erosion of Guns. Mr. Vieille's theory that erosion is due to softening or melting of the surface metal and to the mechanical action of the rush of gases past the projectile before effective sealing is achieved by the driving band. Maj. Charbonnier's criticisms of this theory, and his own theory that erosion is due to the scouring action of the gases following the projectile, i.e. that it is a mechanical action producing wear in the same way as sandblasting does.

Professor Tchernoff's theory that erosion is mainly due to expansion and contraction of the metal of the bore as a result of firing which strains the metal beyond its elastic limit and causes small surface cracks. According to Tchernoff if the temperature of the gases liberated by firing the charge could be kept down to 1000 erosion would not take place.

If the "life" of a gun be taken as the total time during which projectiles are passing down the bore it may be said that the life of a 12-inch gun is approximately 5 seconds, and that of an 18-pdr. 50 seconds.!

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PRÈCIS OF
REVUE MILITAIRE SUISSE.

By Captain G. de L. Landon, M.C., R.A.

April, 1917.

Cavalry Study.

Conclusion of two previous articles in the February and March numbers. The author summarizes the lessons to the drawn from the action of the German cavalry during the war of movement, and endeavours to show that the value of cavalry has by no means declined as a result of the experience of the present war. He admits that the day of shock action, except in a pursuit of demoralized troops, is past, but lays stress on their value in dismounted action, and their special suitability for filling up gaps and forestalling a break-through. He does not consider that all wars in future will be wars of attrition, points out that only a war of movement can obtain a decision, and ascribes the prolonged duration of trench warfare in the present struggle to the fact that the Germans are obliged to fight on two fronts. While making no secret of his admiration for the German cavalry he pays due credit to the action of the British and French cavalry during the Retreat, and the first Battle of Ypres.

The Italian Theatre.

Having recounted the different conditions in the various portions into which the Italian front is divided the author proceeds to a narrative of the great Austrian offensive from the Trentino towards the plains of Lombardy, in 1916. He maintains that to be successful, such an offensive must be combined with an offensive from the East against Tsonzo, and ascribes the Austrian failure chiefly to their neglect of this fact.

The training of infantry for battle.

Conclusion of article in the March number. The author goes very thoroughly into the question of individual training and lays stress on the importance of perfecting company *drill* before starting *manœuvre* exercises.

Chronique Internationale.

Deals chiefly with the entry of the United States into the war, is very eulogistic of the action of President Wilson, contrasts his

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pacifism with that of the Russian extremists, the one being the logical pacifism of a cultivated man, the other being that founded either on complete ignorance or on mysticism, and finally concludes that the cause of the Central Powers is lost.

May, 1917.

Les campagnes allemandes d'Occident.

A strategical study of the campaign on the Western Front from its commencement to the end of the race to the sea culminating in the Battle of Flanders, Oct. and Nov., 1917. A clear unprejudiced narrative without maps enabling the reader to grasp the main outlines of the campaign without the necessity of careful study.

Le théâtre des opérations de l'armée italienne.

Continuation of an article in the last number describing the Italian theatre. An interesting description of the difficulties of terrain with which the Italians have to contend illustrated by excellent photographs. Also an account with map of the Italian offensive of 1916 terminating with the capture of Gorizia on the 9th August, 1916.

Impressions du front Austro Mongrois VI.

Continuation of previous articles by a Swiss officer attached to the Austrian army. The present article deals with operations in the Haut—Isonzo, and gives a good idea of mountain fighting and the types of men and material employed.

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Books on Sale at the R.A. Institution.

The following are some of the works now on sale at the Royal Artillery Institution and will be forwarded to Members only, at the prices noted after their titles below:—

	s.	d.
"Modern Artillery in the Field." By Colonel H. A. Bethell, late R.A. A description of modern technical and tactical methods of employment of Artillery in the field. Fully illustrated. (Plus postage, abroad 8d., at home 5d.) ...	7	6
"Gunnery in the Field." Being Part III (Practical Gunnery) of Modern Guns and Gunnery. By Colonel H. A. Bethell, late R.A. (Price post free)	2	3
Nomography, or the Graphic Representation of Formulæ. By Major R. K. Hezlet, R.A. (Post free).	2	6
"Interior Ballistics." By Lt.-Col. R. K. Hezlet, D.S.O., R.F.A. (Post free).	1	6
"Logarithmic Slide Rules," (1899) a pamphlet, by Major S. B. von Donop, R.A. (Post free).		5
"The Field Artillery Telephone," (Portable, D. Mks. II and III). Revised edition with amendments. By J. Young, Instr. in Science, R.M. Academy, 1915. (Price post free)		7
"Hints on Training the Intelligence and Powers of Observation of Officers, N.C.O's and Men." By Colonel L. W. Parsons, C.B., R.A. (Post free).		3
"Notes on Marching a Battery." By Major W. F. Blaker R.F.A. (Post free).		3
Major Hill's "Slide Rule for Indirect Fire" for 13-pr. Q.F. and 18-pr. Q.F. Guns, 4.5″ Q.F. Howitzer, 5″ B.L. Howitzer, 15-pr. B.L.C. and 60-pr. B.L. Guns. Post free).	14	0
10″ Celluloid Slide Rule. (Post free).	17	6
"Morals and Maxims for Stable Management and Horse Mastership." By Major R. S. Hardman, R.F.A. (Post free).		3
"The Young Officer's Don't, or Hints to Youngsters on Joining." By Major-Gen. Sir D. D. T. O'Callaghan, K.C.V.O., with a preface by Col. Sir G. S. Clarke, G.C.M.G., F.R.S. 2nd Edition. 1907. (Post free).	1	2
"Field Gunner's Catechism." By Lieut.-Col. A. T. Anderson, R.F.A. (Plus postage.) (Reprinting.) ... ... net.	1	6
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PRACTICAL HORSEMASTERSHIP IN THE FIELD.

By Lt.-Col. P. T. C. Herbert, D.S.O.

Horsemastership may be divided into two sections:—

A. Control or Supervision.

B. The care of horses whether in the lines or working.

A. CONTROL OR SUPERVISION.

WHAT everyone is looking for is to get the maximum of efficiency with the minimum of trouble. To attain this you must practise decentralisation, i.e. you must split up the horses of Units, Artillery, Infantry, Engineers, etc., into such small numbers as one man can easily control, and look after, and know all about. The maximum number that one man can be expected to control should never exceed 40, preferably 30. These numbers will actually depend on the Unit you are serving with. If you have 180 horses to look after, split them up into 30's, and give each 30 to an N.C.O. and tell him those are his command, that he will be held responsible for them, and that he will be judged by the condition in which these horses are kept. You serve two good ends in doing this. First you get the animals looked after. Secondly, you make a valuable N.C.O. Give a man his own show as early as possible in his career. A man with an incentive to work will generally do better than a man who has an allotted task and who knows that whether he does it well or badly the praise or the blame will be taken by someone else. For obvious reasons anything like a one-man-show is to be deprecated on service. You must start a system by which the loss of one man does not affect the running of the machine. If you have one man in charge of a large number of horses and something happens to him, it is very hard to replace him, and it takes a long time for his successor to pick up the threads. But if the unit is decentralized and broken up into small numbers, and the horses controlled in the way I will indicate, the loss of one or two men can be easily repaired. In the old days, 2½ years ago, when I was inspecting, some of the best units were what I call one-man-shows, and it was very hard to have to point out to the Commanding Officer that while we admired his work, the idea

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of one-man-control was hopeless on service. Now, if you have taken my advice and have split your units up into such small numbers or sections that they can be readily controlled by one man, the system I want you to start will render any unit, quite independent of who is in command: in other words the officer in charge of horse lines should be like the O.C. of a Battalion, responsible for the whole, but not interfering with the individual Company Commanders. To give a practical illustration. If the O.C. Horse Lines of a Unit wants to find fault with a driver or wants to point out something, he does it through the man who is in charge of the small section of horses that the man belongs to. We all know that practice and theory are not the same thing and that often an officer will have to give orders to a man as there is no time for anything else. But I think you will follow me in my idea. I mean: the way to get the best work out of a young N.C.O. is to treat him as if he had a command of his own; praise him or blame him; both will be passed on you may be sure. This plan may sound hard to work out and not worth the bother: you try it and I expect you will tell me after a bit, how much easier it is to run your units. Now say you have suitably sub-divided your units. I never interfere with the actual subdivision, that is a domestic arrangement. (In my own Regiment the actual subdivision is into sub-sections). The horses of each sub-unit should be handed over to the N.C.O. detailed, and he should be provided with an A.B. 136 easily carried in the pocket.

The book should be kept in the transport or wagon lines and not taken to the trenches or gun positions, except when the entire sub-unit goes out. If the Commander of the sub-unit has to go out on duty he will hand over the book to the man whom he leaves in charge.

One page will be devoted to each horse.

The name of the N.C.O. in charge of the sub-unit should be kept up in a page at the end of the book and initialled by an officer each time a change is made.

A page at the end of the book should be kept for horses with special feeds and entries should be erased when the horse resumes normal feeding.

In the column under "Remarks" should be included any peculiarities—bad illness, date of clipping, etc., and most of all date of shoeing and examination of teeth.

The book should be examined weekly by an officer to see that it is up-to-date and produced on all inspections.

By this system every single horse is known and gets individual attention. It is a trouble to start, but once started it will repay you. In the old days if I wanted to know anything about a horse, it took a long time before anyone was found who knew all about him. Start this system and there will always be a man with a book who will give you a complete detail of any particular horse. If it does nothing else it helps an Inspecting Officer. If he sees something wrong with a horse and there is someone there who knows all about the horse and is ready to note anything of value in his book, he knows that, though there may be some temporary trouble, it will be speedily put right and he knows that the unit is being well cared for. By this plan a

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sub-unit can be handed over in five minutes, the man taking it over will know all there is worth knowing about any horse, what he does best and any other tips of value. Call horses by their pet names if you like, but also always have them numbered so that a stranger can soon know all about them. I think you will agree that this system provides some cure for the frequent changes in Command incidental to Active Service. I do not think there is anything more to be said about control. My system, I know, is a "counsel of perfection". Try it.

B. CARE OF HORSES.

This may be divided into two headings:—

1. Horses in lines.
2. Horses on the march.

1. Horse Lines.

These are now marked out and a Unit has to occupy a selected site. The only advice to be given under this heading is to be very careful when leaving lines to hand them over scrupulously clean, detail an experienced officer to stay behind with a sufficient party, and remain until he is satisfied, and finally obtain a certificate from the incoming officer.

Lines should at all times be kept clean, encourage the N.C.O's in charge of small groups of horses to vie with each other as to who can keep his part of the lines cleanest.

Refuse should be burnt daily, care being taken not to mix mud with the other refuse, as this prevents proper combustion.

On the end post of each picket line fasten a tin and make men deposit in it any nails found in the lines. A frequent cause of injury to horses is that .303 ammunition clips are dropped in the lines. I saw a case recently of a horse who had trodden on a round and punctured the sole of his foot.

Do not leave lying about the loose ends of wires taken from bales of forage.

When lines are taken over do not say to yourself "We shall only be here a short time, it is not worth bothering about comfort." Get the men to work hard for a day or two, it will well repay them later on. Make raised paths from where the men live to the horse lines; if you cannot get "duck walks" get rubble or the small branches of trees or anything that will tend to keep the men out of the mud; do all you can to keep the men grooming the horses out of the mud; let officers remember that for once they go into the lines, a man will go six times. Dig drains to run the water off and keep them clean.

Picket lines. If possible get posts high enough to support two lines, one breast high for the horses, and the top one for the hay net; you want to keep the hay net off the ground but you don't want the horse line too high as it may stop horses lying down and they will get under it.

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If you are compelled to use a line joined to another line with a hook, frap the hook with cord, as it is a frequent cause of injury to horses eyes and nostrils.

Exits to fields. When in lines exposed to possible shell fire, never be content with only one way out. If you have to harness up in a hurry and get out, you will appreciate having several exits; it will probably only mean making a hole in a hedge or bridging a ditch.

Wind screens. In winter in places where no stables or cover are provided, always erect a wind screen. Nothing starves a horse and tucks him up like a cold wind blowing on him all day; a screen erected to windward of the lines according to the direction of the prevailing wind, even if only 6 feet high, will do much to shoot the wind over the lines.

A few posts with branches of trees laced between them makes a good screen.

If you are compelled to picket a horse away from the lines place him as close as possible to his own sub-section. Never fasten his head rope to a picket flush with the ground, as if he gets frightened he may get his hind legs caught and injure himself. Shackle his fore foot to a post driven flush with the ground, have the shackle about 2 feet long, not longer, or tie him up to a post 3 or 4 feet high, and he can run round that and not hurt himself. If the lines permit of it isolate cribbers and wind-suckers—the habit is catching. It is best to shackle a cribber by a fore foot.

Forage. Build shelters for your forage and in winter always have something between the ground and the forage.

Harness. Similarly as far as possible erect shelters for your harness and at any rate always have racks near your sub-sections, and keep harness out of the mud.

Food—oats. Feed at least four times a day, and never give a corn feed without chaff. Encourage the young N.C.O's in charge of small groups to think of how each horse is doing, it makes all the difference to some horses if they can get their oats bruised, others want a great deal of chaff to stop them bolting their corn, some horses do better if 2 or 3 times a week they can get their evening feed soaked and mixed with a little bran if available, in short get the N.C.O. to study each horse and not to feed them all as if they were machines, he can always, through his officer, get advice and help from the Veterinary Officer.

Hay. Where no other chaff is provided at least one-third, and better one-half, of the hay should be chaffed. Always give the remainder in a hay net, never feed off the ground. Give the bulk of the hay at night—it keeps horses quiet.

Watering. Water four times a day. Never water if possible out of a bucket. If troughs are not provided, rig one up with water proof sheets or canvas. Let the N.C.O. in charge of groups always see his own horses watered and fed.

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Light draught horses are entitled to 12lbs. of hay and only 10 comes to railhead, the remaining 2lbs. are drawn from the supply. It may be straw for chaff, or linseed cake, or green grass, or roots in the winter. See that they get it every day. When possible draw a proportion of bran in lieu of corn, and give horses a bran and corn mash 2 or 3 times a week. If near a village try and get the Supply Officer to get you brewer's grains, it makes a good night feed for a horse, but never keep these grains more than a few hours as they get sour.

Too much value cannot be placed on chaff. It makes a horse eat slowly and makes him chew, which causes the flow of saliva which helps to digest the food. Salt is very valuable and can be supplied. A pinch of salt should be given with each evening feed.

If horses at first do not seem to like brewer's grains, do not be discouraged from giving it to them, they will soon get to like it—always add a pinch of salt.

Nose-bags. These should be turned inside out and exposed to the air, and if possible the sun, for an hour every day (the latter advice would perhaps be more useful in a land where there was any sun) and once a week they should be scrubbed out.

If this is not done, and more especially if you are able to give the horses wet mashes now and then, the nose bags become very foul. Try and keep a small surplus of hay nets and nose-bags, and remember that if you want anything from the Ordnance, you must ask for it a month in advance. If you are temporarily short of nose-bags a few supplementary ones can be made out of corn sacks by your saddlers, but do not make more of these than is absolutely necessary, because the sacks are valuable and have to be returned.

Thin horses. The most frequent cause of horses becoming thin and debilitated is malnutrition, and this very often is primarily due to horses not chewing their food. The action of chewing produces salivation, and it is this acting on the gastric juices which helps the process of digestion. One of the reasons that causes horses to bolt their food and not chew is that the edges of their grinders become sharp. Prevention is better than cure, therefore do not wait until the horse has become thin and debilitated before examining his teeth. Every time a horse is shod let his teeth be examined, and if they are rough, get the veterinary officer to attend to them. The date of inspection of the teeth should be entered at the same time as the date of shoeing; it is a trouble but if you only save one horse a month it is worth it.

As a rule do not give thin horses more corn. Their trouble is that they are probably not digesting the amount they are already getting, and if you add more you will only increase the trouble. Whether or not a horse is digesting what he gets, can only be told from his droppings. Get them as much of other extras mentioned above as you can, but always remember that the best food and best medicine you can give a horse is grass that he finds himself.

The best way to exercise all horses that have been doing hard work and want a rest, especially debilitated horses, is to keep the

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weight off their backs, and have them led out to crop grass. Always stand thin horses next each other on the end of a line, a thin horse between two fat ones will get thinner, as they take his food.

When horses work at night especial attention must be paid to them when they return. Remember they will be tired, and when animals are tired their powers of digestion are at a low ebb.

If you can get bran for a hot bran and corn mash, it is very valuable at this time, add salt to it and it is very palatable to a horse, and more easily digested than hard corn. If you cannot get bran try soaking the oats. Give them a small feed of corn and as much hay as possible. If you give a large feed of corn the horse will be too tired to chew it, and it will probably be undigested, and the next day the horse looks tucked up.

In one unit I commanded, we worked out a regular system of relief. When the sentry heard the wagons returning, he put on some water to boil, called the relief, some of them made a mash for the horses and others made something for the men, and when the horses had been watered, the drivers who had been out all night went away and a relief took the horses over. This is a little trouble to arrange, but when you are doing regular night work it is not difficult, and the men get to appreciate it; always be thinking of the comfort of your men and horses, it will repay you.

Fitting harness. There are now plenty of experts about; get the harness once properly fitted and never let one horse go into the harness of another horse; a visit to any of the many horse shows will show people how harness ought to look like; these shows are most valuable as setting a very high standard of excellence.

Harness should be frequently stripped and dubbed, it preserves the leather and prevents galls.

Shoeing. This is, after the care of the teeth, the most important part of horsemastership. On service a horse should never go over a month without having his shoes removed or changed. The toes become long and if you suddenly have to go to a place where you cannot shoe horses for a week or so, this might happen at any time, and when you have to march again, you will lose a lot of shoes, and on these pave roads, this means a lot of lame horses with bruised feet. Here comes in the value of the shoeing lists, if the Farrier happens to forget a horse, the N.C.O. in charge of a small section of horses will note by his book that such and such a horse's time is up and draw the Farrier's attention to it. Officers should frequently have out for inspection all horses shod the day before, this gives a rough idea how the shoeing is getting on, he should then inspect a certain number of feet. I have been asked by officers what is the good of their inspecting feet when they know nothing about it. It is part of their duties, a most interesting subject, and will repay a little trouble. The Veterinary Officer or the Farrier will always be only too glad to help young officers to acquire a certain amount of knowledge, no good farrier minds having his work looked at. There are four cardinal points in shoeing that an amateur after practice can understand and criticise.

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1. *The preservation of the frog.*

This is very important, it is a pad put in the heels to prevent concussion. The way to get a good healthy frog is to develop frog pressure on the ground, if there is no pressure the the heels become wired in and contracted, and the frog gradually disappears.

2. *The length of the heels.*

These should not be too short, especially in heavy draught horses, but they must not be too long, or when a horse is working in heavy going he is apt to overreach and tear off his shoes.

3. Seat the shoe well in to prevent brushing or speedy cutting, i.e., let the horn of the foot if anything slightly project beyond the shoe, so that if the horse does hit himself he will not do much harm.

4. *Avoid dumping the foot.*

When the foot grows, it must be taken down from underneath by rasping. To make a shoe look a better fit sometimes the horn of the foot is rasped in front—this is fatal as it takes away what nature has put on the foot to keep it in health. Frequently examine feet in the lines—there are many nails about.

Brushing and speedy cutting.

These are largely obviated by careful shoeing. They are due either to weakness or malformation; if due to the latter cause try to alter the shoe so as to remove the cause. Supposing the off fore is being injured, try to get the seat of injury further away from the foot that is causing the injury. Try very slightly raising the inside quarter of the shoe of the leg that is being injured; this will tend to throw the fetlock a little out of the line of fire. Great care must be taken not to raise the quarter too much as it will tend to throw undue strain on the suspensory ligament and any dodges of this sort should be tried with the consent and under the eye of the Veterinary Officer, but do what you can to obviate brushing. If you must do so, wear a brushing boot, the best is the ordinary dealer's boot, a piece of cloth, secured to the leg by a piece of tape, and then folded over. Try the dodge of raising the inside quarter very little, about ⅛th inch at first, if the horse still brushes, wear a boot till his time of shoeing is up, and then raise the quarter a very little more. I have tried this with race horses with complete success, a horse only just touches himself, and a very slight alteration is all that is necessary.

Disease or illness.

These are veterinary matters, and all we have to consider is the detection of trouble and reporting it. If an illness is taken in the earlier stages it is generally easier to cure. What aggravates ailments like coughing or slight lameness, is the animal being made to work while in this condition. It is criminal to work sick or lame horses.

2. *Horses on the march.*

Never let a wagon leave the lines without nose-bags and hay nets with a feed in them and a bucket for watering. When going into a waterless country try and carry enough water in tins to give the horses even a little water.

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Halt as soon as possible after leaving the lines and especially after leaving ammunition dumps, to pick up and inspect horses feet for nails.

Halt frequently as far as traffic conditions will allow and see that the N.C.O's in charge of the small groups of horses inspect them for harness galls and have their feet examined. Get the weight off the horses backs as much as possible. Never let men remain mounted when it is possible to dismount them, and never keep a pack on an animals back when it is in any way possible to relieve it of its load.

Get officers to move about their commands and watch how horses work and how the men drive, a lot of debility is caused by bad driving, allowing one or two horses to do all the work.

HORSE BOOK.
UNIT.
INSTRUCTIONS.

1. This book should be kept in the Transport or Wagon lines. It should not be taken to the trenches or gun positions. In the case of Artillery when the Battery is not in action it should be in possession of, and kept up-to-date by, the proper No. 1 of the sub-section. At other times the acting No. 1 at the wagon line will keep it filled in up to date. In the case of other units it should be kept by the N.C.O. or man in charge of the sub-unit.

2. One page will be devoted to each horse. Entries will be made with a non-indelible pencil. The information under each heading must be complete.

3. The list of N.C.O's or men in charge of sub-units must be kept up and initialled by an officer every time a change is made.

4. A page at the end of the book should be kept for horses with special feeds and erased when normal feeding is resumed.

5. Under "Remarks" should be included peculiarities of horse, bad illness, date of clipping, etc.

6. This book should be examined weekly by an officer and produced at all inspections.

PRO FORMA "A".
SPECIMEN PAGE FOR BULK OF BOOK.

Batty. No. or Unit.	Sex.	Place in team.	Date joined.
65	Mare	No. 1 Charger.	5-8-15

Date last shod.	Teeth. Examined.	Teeth. Rasped.
6-7-17 9-8-17	6-7-17 9-8-17	6-7-17

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DESCRIPTION AND COLOUR.

Black.	**White tip on heel O. Hind.**	**Three White patches on back.**

REMARKS.

Good out rider also draft horse, but should be pegged out as she kicks when feeding.

PRO FORMA "B".
SPECIMEN PAGE NEAR END OF BOOK.
N.C.O's, GUNNERS, DRIVERS, ETC.
NOMINAL ROLL—"C" SUB-SECTION.

No.	Rank.	Name.	Religion.	How employed
63829	Sergeant	Scutt, H. E.	C. of E.	No. 1.

PRO FORMA "C".
SPECIMEN PAGE NEAR END OF BOOK.
"C" SUB-SECTION RIFLES.

No.	Bolt No.	In charge of

PRO FORMA "D".
SPECIMEN LAST PAGE OF BOOK.
LIST OF NOS. I.

Name.	Date taking over.	Date handing over.	Officer's Initials.
Sgt. H. E. Scutt	5-5-17	2-6-17	J.B.

PRO FORMA "E".
SPECIMEN INSIDE COVER AT END OF BOOK.
FEED.

12lbs. Oats.
10lbs. Hay.
2lbs. Straw (or green forage when available).

TIMES OF FEED.

7-30 a.m.
12-30 p.m.
5-30 p.m.
8- 0 p.m.

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USE OF STARS FOR ARTILLERY PURPOSES.

By Major M. R. C. Nanson, R.G.A.

MUCH has been written about the use of stars for obtaining directions both for marching and for artillery purposes.

For artillery purposes generally some approximate method has been advocated. As there is no difficulty in an exact method, a description of it may be considered useful by some readers of this article.

The exactness depends on the instrument and the tables which you use and you can test your accuracy by trial, so that if you make up your mind with regard to the degree of accuracy with which you will be content, and give the method a trial with the instruments which you possess, and the tables with which you care to provide yourself, you will be able to form a just opinion on the value of a star bearing, as far as your particular battery is concerned.

The examples which will follow are produced with a No. 5 director, eleven pages out of the Nautical Almanack (price 2/6) entitled "Mean places of stars", the log sines, cosines, etc. tables out of "Hints to Travellers", the star map of Northern constellations out of "Hints to Travellers", and the mean Astronomical refraction table out of "Hints to Travellers", all of which, (if you are an enthusiast on reducing bulk,) can be compressed into a very small space.

The procedure is to set up the director, level it with the bubble attached to the telescope by varying the lengths of the telescope legs on the same principle that you level a D.R.F.; identify stars towards East or West with the aid of your star map. Observe one of these and note its elevation and it horizontal angle from any zero.

Example:—East star β Leonis 69° 22′ Right of zero and at elevation 11° 49′ look up the refraction and substract 4′ for it which gives

you 11° 45′ (h) below this write your latitude 50° 50′ (ϕ) (say) and below this the polar distance 74° 58′ (p) which is the difference between 90° and the declination "N" of β Leonis taken from the "mean places of stars".

Take the sum which equals 137° – 13′

L sec	10·448499	halve it	68° 36′ (s)
L sec	10·002687	$(s)-(p)=$	6° 22′
L sin	9·484501	$(s)-(\phi)=$	17° 46′
L sin	9·922520	$(s)-(h)=$	56° 47′
sum =	19·858207		
half sum =	9·929103 = log tan 40° 21′.		

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Take out log secants and log sines as indicated for these last four angles.

Obtain half the sum of these logs and look up the tangent corresponding to its value.

Double this angle = 80° - 42′ which is the true bearing of your star.

The true bearing of your zero is 80° 42′ - 69° 22′ Right of True North = 11° 20′ Right of True North.

For a test of the value of your work take a West Star, for example α Pegasus.

Observed	101°	45′	L of zero	Elevation		18°	12′
Computed	88°	46′	L of True North	Refraction			3′
zero is	12°	59′	R of T. North	(h)	=	18°	09′
				(ϕ)	=	50	50
				(p)	=	75	15
				2		144	14

L sec	=	10.512749	s =	72	07
L sec	=	10.000650	$s-p$ =	3	08
L sin	=	9.559883	$s-\phi$ =	21	17
L sin	=	9.907774	$s-h$ =	53	58
		19.981056			
		9.990528	= L tan 44° - 23′		

The above two examples are two particularly bad observations owing to a particularly badly levelled instrument; the mean of these two results namely ½ (11° 20′ + 12° 59′) = 12° 10′ R. is probably less than 10′ in error and when trouble is taken to carefully level the instrument an East and a West result will not differ by more than 5 minutes.

The following is an example with the sun, the declination of which you will find elsewhere in the almanack.

		2° 22′	elevation at 49° 20′ L of zero
		- 17′	refraction
		- 16′	semi diameter
(h)	=	1° 49′	
(ϕ)	=	50° 50′	
(p)	=	70° 59′	
		123 38	

s	=	61 49	L sec	=	10.325787
$s-p$		9 10	L sec	=	10.005582
$s-\phi$		10 59	L sin	=	9.279948
$s-h$		60 00	L sin	=	9.937531
					19.548848
			L tan	= 30° 45′	9.774424

49°	20′
61	30
12°	10′ R.

Two figure logarithms would be sufficient.

Your latitude is obtained from a small scale map.

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Another Example.

α Pegasus E star
123° – 48′ E of zero

elevation		35°	16′
refraction			1′
h	=	35°	15′
ϕ	=	50	50
p	=	75	15
2		161	20
s	=	80	40
$s-p$	=	5	25
$s-\phi$	=	29	50
$s-h$	=	45	25

L sec	10.790008	
L sec	10.001944	
L sin	9.696775	
L sin	9.852620	
	20.341347	
L tan 53° – 59′ =	10.170673	

× 2 = 111° 58′ E of zero. ∴ zero is 11° 50′ R of zero

α Bootis W star
71° 13′ W of zero

elevation		19°	59′
refraction			3
h	=	19°	56′
ϕ	=	50	50
p	=	70	23
2		141	09
s	=	70	35
$s-p$	=		12′
$s-\phi$	=	19	45
$s-h$	=	50	39

L sec =	10.478293	
L sec =	10.000003	
L sin =	9·528810	
L sin =	9.888341	
	19.895447	
L tan 41° 34′ =	9.997723	

× 2 = 83° 08′ W of zero
zero is 11° – 55′ E of zero.
or R of zero.

If you take your zero as the magnetic north given by your director, the result is the difference between true north and the magnetic north given by your director in its present position which may be temporarily affected by a tramway line or other metal and thus be useless. However, the difference between true north and the grid north of your map is generally given on the map; if it is not given it may be obtained for the Western Front by dividing the distance from Brussels in yards to your position on the map by 1700; the distance from Brussels to some point on your map is given on the map; if this is given in metres instead of yards, divide it by 1560 instead of 1700.

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As the compass varies with time, place, and locality it is a good thing to be independent of it not only on the ground but also on the map.

The obtaining of a line from the identification of two points on the map is frequently difficult, and the magnitude of its error is often increased by being forced to take too near an aiming point, and would be still further increased if it were necessary to make use of a small scale map.

Hence, the capacity of being able to take a true bearing and to use map true bearings either by means of protractor or calculation may in future be invaluable to long range artillery in obtaining an accurate enfilade of a road.

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CO-OPERATION OF ARTILLERY WITH AIRCRAFT.

By Major T. N. French, R.F.A.

OFFICIAL literature in the form of Pamphlets, Notes, Directions, during recent times has been so obviously written by experts —and genuine experts not theorists—that it seems not only redundant but impertinent to attempt to elaborate or explain further.

However, the subject on which I write is so new, and there is so much yet to be learnt by practical co-operation that attempts at standardizing may lead to lack of initiative, and are therefore to be deprecated. On the other hand simplicity and fixity of procedure are so very vital to success that I venture to write on the subject and draw attention to certain common causes of failure, and urge some standard method be adopted.

As a B.C. if you have once learnt to do successful shoots with an aeroplane, as far as your end is concerned you should never have a failure again, no matter what army you may happen temporarily to be in. There are lots of things to be remembered, but they are all simple, and chiefly require attention to detail. Your success or failure will, without a shadow of doubt, reflect the excellence or otherwise of your battery. Is it quick? Is it accurate? It is. All right, every time that you have a good pilot and good visibility you ought to bring off a good shoot. A few suggestions:—

(1). Don't practise one of your young subalterns, he won't work out the meteor, or translate the observations into corrections as accurately or as quickly as you can yourself.

(ii). Don't be sketchy about your ground strips. You have got to find a man to work the ground strips, it isn't part of the job of the R.F.C. wireless operators; see that he knows how to, and can put them out quickly.

(iii). Be certain that the position of the ground strips is well selected, is approved by one of the pilots of the squadron you work with, and of course never change their position without letting your squadron know.

(iv.) Accept the observations sent down as being correct. If the pilot sees the round it is not difficult for him to pin point it. All the ground observation difficulty of confusing line and range is obviated from his position. There is a tremendous temptation to a pilot when things don't seem to be going right to 'correct' instead of to

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observe, but they are so stringently forbidden to do so that it very rarely occurs. If he does the shoot will be a 'failure' (of which more presently), equally it will pay you to accept his observation as accurate.

(v.) Speed is of vital importance. Remember (a) that artillery observation is very far from joy riding, the strain of much flying is enormous; (b) If you do not get off your allotted number of rounds a relief will have to come out with consequent waste of available time for artillery work, and extra work on the Squadron. (c) Your relief cannot take as much interest in the shoot, and will not have the same hang of your and the enemy Battery positions as the man who has been shooting on it for 3 hours. (d) A long shoot will probably not be a good one for many reasons, e.g. meteorologic conditions.

(vi.) Do not cease firing every time your more or less amateur aeroplane scout reports enemy aircraft. Your Squadron Commander, if you ask him, will be delighted on a 'dud' day to send down one of his pilots or observers to teach you to distinguish our own and enemy machines and to instruct you when they are likely to be looking for you, or to see you well enough to locate accurately your position.

(vii.) Don't say 'My piece cannot lie to me'. The remark is often quite meaningless; when it was new its truthfulness (i.e. accuracy) was vouched for, and based on tests carried out by experts under experimental conditions. It is probably no longer new. After a certain amount of wear although there may be no question of condemning it, yet no one can work out its absolute definite performance. And its truthfulness or accuracy (pace oh! scientific garrison gunner) is entirely found by our own deductions and calculations based on hypothesis. One often hears a B.C. say 'I cannot account for it at all', but really and truly he accounts for it to himself all right by either saying the observer is an incompetent ass, or that meteor was wrong.

Now as to methods in carrying out a pre-arranged counter-battery shoot. As I said before, it is possibly not wise to standardize too much, as long as the method is sound, that is the only vital thing. Let me outline one method of carrying out a shoot with a single battery on one enemy battery. The Pilot goes up with information on the following points: your position, your call, your piece, your time of flight, the pace at which you can take G's after you have got to Battery Fire, and a ringed photograph of the target. You will have been warned previously by the daily programme. He calls you up on his way over to inspect his target, get your strips out at once, and have your guns layed and loaded. He next warns you to 'stand by' and gives you your target to obviate all possibility of misunderstanding. You are ready, so put out your signal at once. He sends you G and you fire your No. 1 gun. He sends you 'Observation and G for No. 2 gun' *in one message*. Fire your No. 2 gun at once; because there is a margin of 10 seconds allowed don't think there is no hurry, you may have a missfire, in which case you should fire No. 3, there may be a hang-fire. The time of flight is X seconds, the pilot has got to predict, and be so placed as to see the target in + X seconds, if it

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comes every time in X + 3 seconds he will miss very few rounds, the strain will be less, and at X + 10 seconds he will know definitely that either you didn't fire or he has missed your round. Has your own temper never worn a bit thin when that damfool subaltern on duty at the battery has not got the guns off at once when you said 'fire' down the telephone? Have you never missed a round because you were not certain when it was fired?

The decision as to when you go to Battery Fire rests in your hands not the pilot's. In this method of carrying out a shoot, meticulous bracketing and verifying of each of your pieces is in my opinion not necessary; provided your guns are well calibrated as soon as you get a fairly close group in 4 consecutive rounds why not go to Battery Fire? If you are only to have observation during the period of ranging it will of course be necessary; but if—as in this method—you are going to fire every round of B.F. on a G and get a 'Mostly' correction for each round of B.F, *AND* your pilot fully understands that if they are not grouping closely he is to send you down observations to that effect, or ask you to revert to single gun fire, why not get to the quicker method? It is a very debatable point and has much to be said on either side, if your guns have very different muzzle velocities it will certainly be necessary to get the M.P.I. of each gun on to the target. When you decide to go to Battery Fire you put out the ground strip to that effect, it does not much matter whether your pilot sees it or not, because when on a G he gets 4 rounds in quick succession instead of one he will tumble to the fact and send you a 'mostly' correction. After that he will send your corrections and later the G at the interval previously arranged; an interval of 1 minute from correction to G is easy to remember and easy to work and not too fast for the battery.

As soon as the first of the enemy's emplacements is destroyed—the decision lies entirely in the hands of the observer, you in the battery cannot possibly know—he will switch you on to the second and so on.

The duration of the flight is limited; if for many of the various possible causes (e.g. missing rounds, interference by enemy aircraft, Archie, etc.) the shoot has been slow and looks like not being finished in the flight the aeroplane will call for a relief who will carry on for you.

Now as to failures.

They are unfortunately inevitable and the only method of as far as possible eliminating them is to leave no failure unaccounted for. Broadly speaking they may be classified under Battery failures, Pilot failures, Act of God failures, and Devilry of German failures.

A machine leaves the ground to carry out a successful shoot if it lands again without having done so, it has been a failure. Whether any particular person is to blame is quite beside the point. The pilot writes out his story, the Squadron Commander, the Battery Commander, the Wireless Officer make their statements or comments, the cause of failure is discovered, and if preventable is should not occur again. It sounds so easy, and yet somehow it isn't always. As a

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Battery Commander don't be resentful if you are asked to make your remarks, if you have been to blame confession is good for the soul, if you can show it was the observer's fault the Squadron Commander will be able to put it right directly he finds out what the fault was, your explanation may help him. The old story, the old motto, 'Let's fight the Germans'; the more efficient each little piece of our machinery is the better we'll do it. Don't be childish.

The efficiency and excellence of aerial artillery observation is no longer merely very desirable, but under modern conditions of warfare vital to success. The Germans are beginning to realize it. We have been the pioneers in this,—contrary to most modern war methods —let us strive to perfect it and eliminate failures and become more and more expert in it. In time to come I believe that the Corps Squadrons will be part and parcel of the Artillery Organization of our Army; a specialized branch of the Flying Corps.

I have endeavoured to touch (very lightly) on only one side of the subject, i.e. the Artillery side, and the Battery Commanders' common failures. Very likely the observer and Flying Corps side more commonly goes wrong. *But it is a matter of co-operation*, and it doesn't matter whether it is shooting with aeroplane observation, or playing Auction Bridge or anything else requiring close co-operation, let each partner perfect his own knowledge and execution and be in close sympathy with and fully understand the other's difficulties and limitations, and play together. I should like to see the methods standardized but above all the principles must be sound.

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ON ACCURACY OF FIRING WITH OBLIQUE FIRE.

By A. M. Grundy, Esq., M.A.
(Instructor in Mathematics, R.M. Academy).

THE object of this paper is to make it possible, when such is desirable, to give a precise answer to the question:—"What is the alteration in effect obtained by oblique fire?" The answer to this question will also indicate how nearly accurate any other method of dealing with the problem really is.

Just as the range table gives the 50% zones for length and breadth, so there exist 50% zones, and in fact any other percentage zones, bounded by lines inclined to the line of fire, and having the mean point of impact midway between the bounding lines.

We will call the 50% length zone L, the 50% breadth zone B and the 50% zone whose bounding lines are inclined at an angle θ to those of L we will call I. The object of this paper is to obtain I when L, B, and θ are known.

This can be effected by means of Fig. 1, by the following procedure. Express $\frac{B}{L}$ as a decimal and locate the chain-dotted curve (an ellipse) in Fig. 1 which is labelled on the left by this decimal. Pick out θ on the outer circle and follow down the dotted line through θ until the curve already noted is reached. The distance of the point so obtained from the centre O, as measured by the concentric circles ·1, ·2, etc. will give the ratio $\frac{I}{L}$ as a decimal.

To take a concrete case:—Suppose that firing at a target which is a trench with bounding lines making an angle 50° with the line of fire, the range table gives the 50% length zone 40ᵡ and 50% breadth zone 12ᵡ how large should the 50% zone whose bounding lines are parallel to those of the target be taken?

Here L = 40ᵡ, B = 12ᵡ, θ = 40°. Find I.

$\frac{B}{L} = \frac{12}{40} = \cdot 3$ and so the curve to be noted is that labelled on the left ·3. Follow the dotted line through 40° till this curve is reached. The point so found is between circles ·7 and ·8 and very near the latter, in fact is ·79 or $\frac{I}{L} = \cdot 79$. That is I = 40ᵡ × ·79 = 31·6ᵡ.

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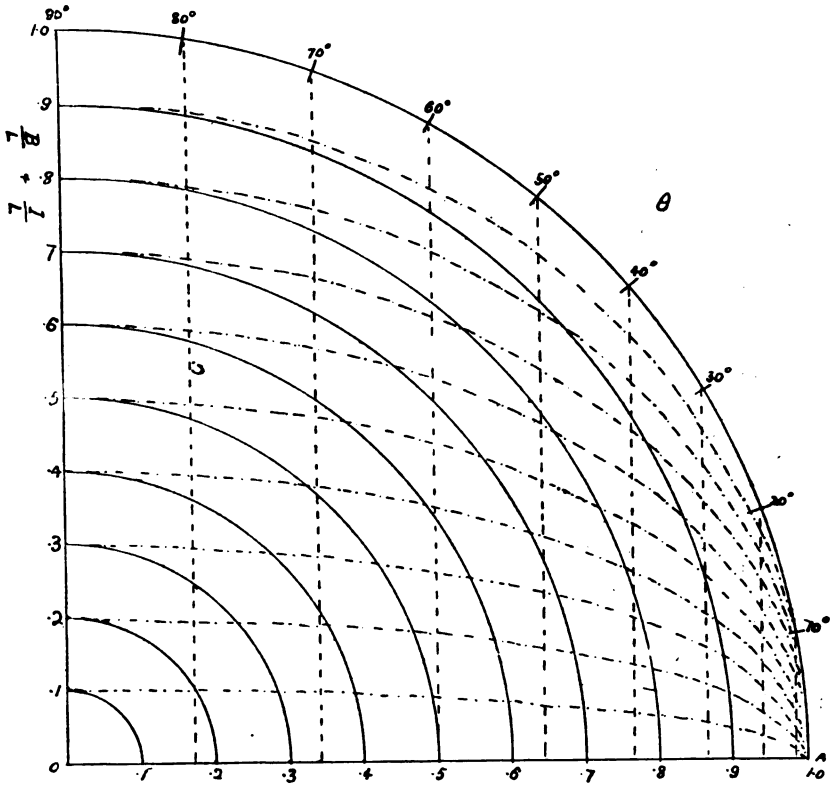

Fig. 1.

Of course when either $\frac{B}{L}$ or θ is not actually marked on the diagram interpolation by eye is easy.

The correct relation connecting I with L, B, and θ is

$I^2 = L^2 \cos^2\theta + B^2 \sin^2\theta$.

If we use the same numbers as above i.e. $L = 40^{\text{x}}$, $B = 12^{\text{x}}$, $\theta = 40^\circ$

$L \cos\theta = 40 \cos 40^\circ = 30{\cdot}6^{\text{x}}$

$B \sin\theta = 12 \sin 40^\circ = 7{\cdot}71^{\text{x}}$

$L^2 \cos^2\theta = 936$

$B^2 \sin^2\theta = 59{\cdot}4$

$I^2 = 936 + 59{\cdot}4 = 995{\cdot}4$

and $I = 31{\cdot}6^{\text{x}}$

It will be observed both from Figure 1 as also from the equation $I^2 = L^2 \cos^2\theta + B^2 \sin^2\theta$ that the ratio $\frac{I}{L}$, which is what really matters, depends on the ratio $\frac{B}{L}$ and on θ. A large value of θ and a

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small value of $\frac{B}{L}$ are both desirable in order to make I as small as possible. In many cases however an increase of θ will entail an increase of range which automatically increases L and generally increases $\frac{B}{L}$. The impossibility of predicting what will be the result of oblique fire is shown in the following two examples the data for which are taken from an old range table.

We suppose that oblique fire can only be obtained by using a gun which is situated along a line perpendicular to that of direct fire.

Firstly take $R = 2000^{\text{x}}$, $L = 23^{\text{x}}$, $B = 1^{\text{x}}$.

For direct fire use $L = 23^{\text{x}}$.

Now moving to a flank so as to fire at an angle of 30° with the old line of fire i.e. $\theta = 30°$

$$R' = \frac{R}{\cos 30°} = 2310^{\text{x}},\ L' = 23{\cdot}3^{\text{x}},\ B' = 1{\cdot}11^{\text{x}},$$ gives $I =$ $20{\cdot}2^{\text{x}}$, showing some but slight improvement.

Taking $\theta = 60°$

$$R'' = \frac{R}{\cos 60°} = 4000^{\text{x}},\ L'' = 25{\cdot}0^{\text{x}},\ B'' = 2{\cdot}20^{\text{x}}$$ gives $I =$ $12{\cdot}6^{\text{x}}$ which is a distinct gain.

If however we start with direct range 5000^{x} for which $L = 26{\cdot}0^{\text{x}}$, $B = 3{\cdot}23^{\text{x}}$

$$R' = \frac{R}{\cos 30°} = 5780^{\text{x}},\ L' = 28{\cdot}4^{\text{x}},\ B' = 4{\cdot}17^{\text{x}},\ I = 24{\cdot}7^{\text{x}}$$

which is again a slight gain.

$$\text{But } R'' = \frac{R}{\cos 60°} = 10000^{\text{x}},\ L'' = 75{\cdot}2^{\text{x}},\ B'' = 10{\cdot}7^{\text{x}}$$ gives $I = 38{\cdot}2^{\text{x}}$ entailing a clear loss of effect.

These examples should be sufficient to show that no general rule can be laid down as to the advisability of oblique fire, each case should be calculated on its merits. Generally speaking for most guns at short ranges L increases less rapidly than the range and B almost always more rapidly and it is impossible to predict in general whether the increase in L and the greater increase in B will or will not outbalance the advantage got by increasing θ. A rough idea can be obtained of the effect of oblique fire by noting the ratio $\frac{L}{R}$ since in most cases L has more effect than B on the value of I. It is in all probability not far from true to say that one is likely to obtain better effect so long as the new value $\frac{L'}{R'}$ is less than the old value $\frac{L}{R}$.

Proof of the relation $I^2 = L^2 \cos^2\theta + B^2 \sin^2\theta$

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We take the mean point of impact O to be origin and draw axes Ox along the line of fire and Oy perpendicular to Ox. Then Ox and Oy each separately divide the fall of shot symmetrically and in the long run for each round which has (x, y) for the coordinates of the point it hits there will be a round which has $(x, -y)$ for its coordinates.

We will also use x to represent the distance any round is distant from the mean point of impact measured along the line of fire and so use x as the typical error of a round for range. In the same way y will be used as the typical error of a round for line.

Now suppose that n rounds are fired and that their errors are $x_1, x_2, \quad x_n$ and $y_1, y_2, \quad y_n$.

Then if we define

$$[E(x)]^2 = \frac{x_1^2 + x_2^2 + \ldots\ldots\ldots x_n^2}{n-1} = \frac{\Sigma(x^2)}{n-1}$$

$$\text{and } [E(y)]^2 = \frac{y_1^2 + y_2^2 + \ldots\ldots\ldots y_n^2}{n-1} = \frac{\Sigma(y^2)}{n-1}$$

E (x) and E (y) are called the mean quadratic error for length and breadth respectively. The symbol $\Sigma\ (x^2)$ indicates the sum of all the x^2.

It is shown in the Text Book of Gunnery that

$1{\cdot}349E(x) = 2L$

$1{\cdot}349E(y) = 2B.$

and so any homogeneous relation such as $I^2 = L^2 \cos^2 a + B^2 \sin^2 a$, if true for mean quadratic errors, must also be true for 50% zones, since the numerical factor $(1{\cdot}349)^2$ cancels out.

Our object is to consider errors in directions other than along Ox or Oy and to do this we take new axes Ox', Oy' inclined at an angle θ with the old as in Figure 2.

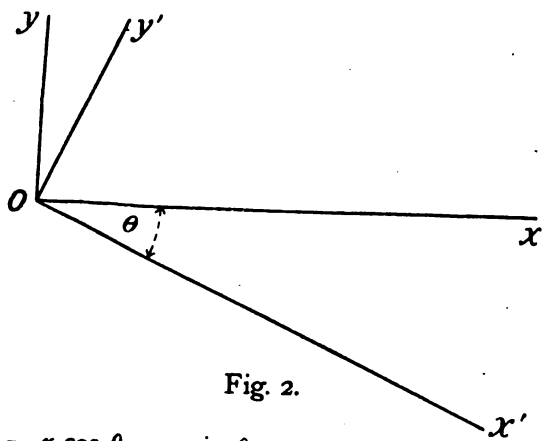

Fig. 2.

Then $x' = x \cos\theta - y \sin\theta$

$y' = x \sin\theta + y \cos\theta$

$$\text{and } I^2 = \left(\frac{1{\cdot}349}{2}\right)^2 \left[E(x')\right]^2 = \left(\frac{1{\cdot}349}{2}\right)^2 \frac{\Sigma x'^2}{n-1}$$

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$$= \left(\frac{1\cdot349}{2}\right)^2 \frac{\Sigma(x\cos\theta - y\sin\theta)^2}{n-1}$$

$$= \left(\frac{1\cdot349}{2}\right)^2 \frac{\cos^2\theta\ \Sigma(x^2) - 2\cos\theta\sin\theta\ \Sigma(xy) + \sin^2\theta\ \Sigma(y^2)}{n-1}$$

The middle term on the right containing $\Sigma(xy)$ contributes nothing, since Ox, Oy divide symmetrically the fall of the shot, and so we get

$$I^2 = \left(\frac{1\cdot349}{2}\right)^2 \frac{\cos^2\theta\ \Sigma(x^2) + \sin^2\theta\ \Sigma(y^2)}{n-1}$$

$$= \cos^2\theta \left(\frac{1\cdot349}{2}\right)^2 \frac{\Sigma(x^2)}{n-1} + \sin^2\theta \left(\frac{1\cdot349}{2}\right)^2 \frac{\Sigma(y^2)}{n-1}$$

$$= \cos^2\theta \left(\frac{1\cdot349}{2}\right)^2 \left[E(x)\right]^2 + \sin^2\theta \left(\frac{1\cdot349}{2}\right)^2 \left[E(y)\right]^2$$

$$= \cos^2\theta\ L^2 + \sin^2\theta\ B^2.$$

So I is the distance from O of the point where coordinates are $L\cos\theta$, $B\sin\theta$. That is, if we draw an ellipse, Figure 3, whose semi-major axis is L and semi-minor axis B its equation $\frac{x^2}{L^2} + \frac{y^2}{B^2} = 1$ is satisfied by the point $L\cos\theta$ $B\sin\theta$. Now the line drawn at an angle θ with L will cut the circle centre O and radius L in the point $L\cos\theta$, $L\sin\theta$ and so the construction employed in Figure 1 is obtained, the only difference being that there the curves are all drawn with semi-major axis = 1 and semi-minor axis $= \frac{B}{L}$.

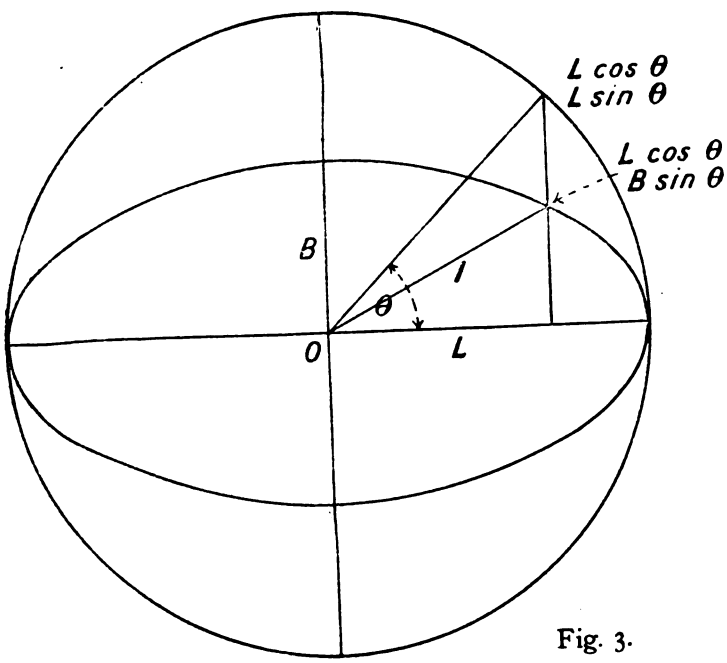

Fig. 3.

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MACHINES V HEAD.

By Major A. E. C. Myers, R.G.A.

THERE is amongst many gunners at the present time a tendency to work with the aid of machines or instruments instead of the head.

Thus we have devices for ranging by aeroplane, devices for plotting the observation of two observers, devices or charts for finding the wind correction, tables for concentration, tables of angles or nomographs for finding factors, slide rules of various sorts, and other devices of various natures in use or suggested. Some of these are clever, some are cumbersome, others solve the problem to a far greater degree of accuracy than is necessary, and there is not much harm in using them *as long as the user can do without them if necessary*. It is not always possible to have the required one handy, but the main objection is that the man who uses an instrument to solve a problem does not use his brain, which may consequently get rusty or slow and the owner may even forget altogether how to solve the problem in his head, or even on paper.

It is proposed to show that no accessory of any sort is necessary, except a range table.

The modern range table gives the effect in yards at every 500 yards of range, of the various factors affecting the range, and all that is required is a little interpolation which anyone should be able to do in the head.

Example. It is required to find the correction at 4300 for a barometer of 29·6. 6″ 26 cwt. how. Charge 3. On referring to the range table the following is seen:

Range	1″ variation of barometer alters range by
4000	13
4100	
4200	
4300	
4400	
4500	16

It is seen at once that 1″ variation for 4300 is 15 and that ·6 of 15 is 9.

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It is useful to insert two additional columns in the range table, one to show the effect of an alteration of 10° difference in temperature of change and the other to show the effect of an alteration of 1lb. in the weight of shell. There is room for the former on the left of the right hand page and for the latter on the right of the left hand page.

It is now proposed to consider in detail the various problems that may turn up.

Wind. It is on this that the inventor has lavished most energy and many are the devices by means of which the effect may be read off.

Now if the wind is straight up or down the range, or at right angles to the line of fire, there is no problem. The effect in yards, can be taken from the range table, interpolating if necessary and without using pencil or paper. If, however, it is at an angle to the line of fire, then it has to be resolved. If x is the speed of the wind and θ the angle which it makes with the line of fire then $x \cos \theta$ is the speed up or down the range and $x \sin \theta$ is the lateral speed. It is to solve this little problem that is the object of the inventor.

It can be got most easily from the slide rule.

But is anything really necessary? If the wind is light its effect in yards is small and some slight inaccuracy in calculating its effect will have very little result. On the other hand, if the wind is high, it will also be gusty and the speed as given is likely to be inaccurate, so that in either case any great nicety in calculating its effect is not required.

Now the following little table which *anyone* can carry in his head solves the problem with an average error of only ten per cent.

To find the speed of the wind up or down the range

Angle	Calculate for
0° – 30°	Whole speed
30° – 50°	¾
50° – 70°	½
70° – 80°	¼
80° – 90°	Nil

To find the lateral speed of the wind

Angle	Calculate for
0° – 10°	Nil
10° – 20°	¼ speed
20° – 40°	½ ,,
40° – 60°	¾ ,,
60° – 90°	whole ,,

Thus by means of this table the effect of the wind in yards can be found without any accessory or putting pencil to paper with an average error of ten per cent.

If, however, a greater degree of accuracy is required, a table of sines to 2 places of decimals could be inserted on a spare page in the Range Table.

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DOUBLE LINE OBSERVATION.

The service grid plotter is an excellent accessory, is on a big scale and requiring no preliminary work, is always ready, but it is quite easy to prepare a grid on squared paper (A.B. 152 will do at a pinch) in a few minutes, giving the result in yards in the ordinary way, or if the result in minutes is required, on the lines suggested by Major Grose in the May, 1917 number of the R. A. Journal. With a little practice, any officer can make himself entirely independent of any accessory.

THE ELEVATION AND DEFLECTION FACTORS $\frac{E}{O}$ AND $\frac{D}{O}$

Whatever the nature of the target, the observer from a flank should have these two factors ready for use if required. A rough approximation is all that is necessary, any nicety of calculation being swallowed up in the zones of the gun. They are usually found by means of the table of angles, nomography, or slide rule.

They can, however, be found by first principles in the head without any accessories as follows:

It is required to find E, D and O.

E = number of minutes of gun elevation equivalent to 100 yards change of range. It is obtained from the range table.

O = the number of minutes at O subtended by 100 yards change of range.

First find how much 100 yards subtends if apex angle is 90°

This can be done quickly in various ways such as—

Knowing that (1) 100 yards at 600 yds. subtends 10°

(2) 100 yards at 3400 yds. subtends 100′

(3) 100 yards subtends $\frac{(60)^\circ}{R}$ when R is range in hundreds of yards.

(4) any old way.

Having obtained this, which should take only a few seconds, add 2 to the first figure of the apex angle (if the angle is less than 20° add one instead of 2) and treating this as a decimal multiply the above result by it. This is O.

Example. O T = 900 yards Apex angle = 50°

100 yds. at 90° subtends $\frac{60}{9}$ = not quite 7° say 400′

O = ·7 of 400′ = 280′

D = the number of minutes deflection at D required to bring a shot that falls plus or minus 100 yards on to the line of observation.

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An easy way to get a rough working approximation for $\frac{D}{O}$ is as follows:—

Calculate $\frac{OT}{BT}$

This can be used as $\frac{D}{O}$ up to 20°:

Above 20° the following is the percentage of error if $\frac{OT}{BT}$ is used as $\frac{D}{O}$

Angle.	Percentage of error.
20°	8
30°	16
40°	32
50°	64
60°	100
70°	200

The above figures run so easily that once seen, they can never be forgotten.

Example. OT = 900 BT 3600 Apex angle 60°

$\frac{OT}{BT} = \frac{1}{4}$ At 60° error = $\frac{1}{4}$ therefore $\frac{D}{O} = \frac{1}{2}$

If further accuracy is required, use can be made of the table of sines which it has already been suggested should be inserted on a spare page in the Range Table.

$$\frac{D}{O} = \frac{OT}{BT \sin (90 - \text{Apex angle})}.$$

Concentration and displacement.

Officers should be able to do any problem of this nature in their heads if required.

Ranging by aeroplane.

No further accessory except a watch is necessary. See R.A. Journal, August 1917, "Ranging by aeroplane".

Anyone working on the above lines will if called upon in an emergency, or during an advance, work infinitely more quickly than if he usually depended on a collection of accessories.

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RANGING BY AIR-BURSTS.

By Lieut. A. Church, R.G.A.

FOR two years now the German gunner has supplemented aeroplane and balloon artillery ranging by ranging by means of ground observation on air-bursts. During the greater part of 1916 his method was to fire "cream-crackers" or "woolly-bears" which burst between 100 ft. and 200 ft. above his objective, and then having got his line and range correct, to go to high explosive with field or heavy howitzers. This method probably gave quite satisfactory results but suffered from two obvious disadvantages.

1. Field guns and howitzers had to be calibrated in conjunction—a difficult matter owing to the difference between the maximum heights of their trajectories.

2. The ranging bursts invariably gave warning to the personnel of the hostile battery or other target engaged.

This year the Germans have modified the method considerably, with the result that they have obviated either both or the latter defect in the system. At the same time they appear to have lessened the possibilities of error by selecting a few well-defined reference points in a corps area, reference points with which his observers could become well acquainted in a very short time. Enough points were taken however and these most carefully co-ordinated to ensure the most accurate results.

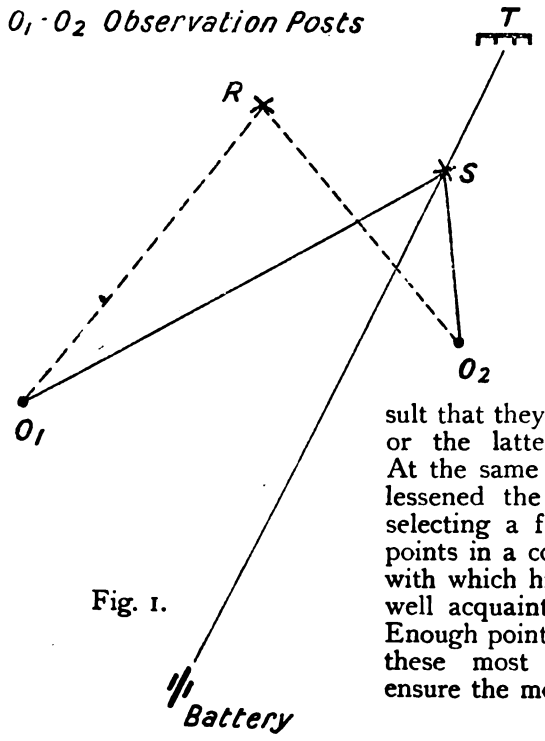

Fig. 1.

Suppose

R—reference point.

T—target.

S—an arbitrarily chosen clamping point on the line Battery—Target.

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The observers at O_1 and O_2 switch from their reference point R on to their clamping point S.

The battery fire a high-air burst—each observer sends through to the battery—

1. Line observation.
2. Angle of sight to burst.

From the line observations an intersection is obtained which gives the distances O_1S and O_2S. From either O_1S or O_2S the height of the burst can be obtained. Small errors in observation do not materially affect the accuracy of the calculated value.

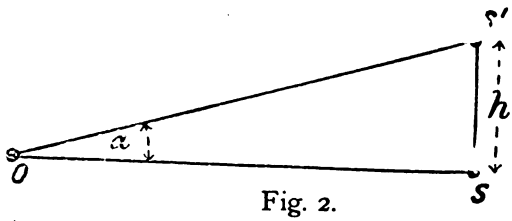

Fig. 2.

h = height of burst = O.S. tan α

The battery continues to fire until satisfied that the line is correct. The point of impact of the shell fired with a direct impact fuze can be found from the height of burst and the angle of descent. It is assumed of course that the tangent to the trajectory and the trajectory are coincident for the last few hundred yards of its path.

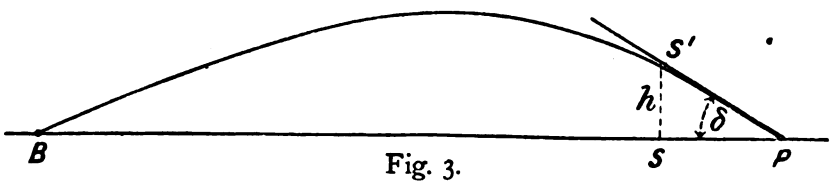

Fig. 3.

$$BP = BS + SP$$
$$= BS + h \cot \delta$$
$$P = \text{point of impact}$$
$$\delta = \text{angle of descent.}$$

BS is already determined from the line observations.

After firing a few rounds to verify the M.P.I. the battery commander can "lengthen"" to his target and go to percussion.

It is hardly necessary to emphasise the fact that this method of ranging can be made extraordinarily accurate. Provided that the map is accurate, the degree of accuracy obtainable can certainly be within the 50 per cent zone of the gun or howitzer.

It is not suggested that such a method would obviate the use of aeroplane or balloon for ranging purposes, but air-bursts can be observed from forward observation posts on comparatively dull days, or days when the weather conditions might otherwise interfere with 'plane or balloon observation. This method might be used with

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great advantage at such times and save a good deal of ammunition which is probably wasted when firing from the map on the results of previous shoots.

It would be useful also during a protracted bombardment or counter-battery shoot for checking the line from time to time during changes of wind, after the aeroplane or balloon observer had ceased to observe for the battery. Experience during the last few months has shown that the Germans invariably adopt these fire tactics for distant targets. Furthermore, it is very doubtful whether any reliance can be placed upon the "Mostly" observations given by a 'plane after a battery has gone to fire for effect. It is exceedingly difficult for a 'plane observer to keep more than one target under observation at the same time, particularly while we adhere to the "clock code."

It may be urged as an objection to the method that only guns could be ranged thus as howitzers do not fire shrapnel or air-bursts of any description. There is no cogent reason however, why they should not. It is quite unnecessary for the air-bursts to be at a uniform height, and quite unnecessary to regard the bursts as potential man-killing agents—in fact, this latter function is almost undesirable for the bursts should be nearer 200 ft. high than 100 feet. Now that the winter is drawing near it might be interesting to experiment with air-bursts from howitzers—at least with 4·5″ and 6″ howitzers, both of which have, I believe, been served with shrapnel in the earlier months of the war.

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A SIMPLE METHOD OF CALCULATING SIZE OF CORDITE.

By Lieut. H. S. Rowell, R.A.

INGALLS' formula for least dimensions of powder grains is rather cumbrous and involves the initial air space and weight of the charge, quantities having no direct physical connection with the problem. The method of the Service text book, though sound and simple, is somewhat lengthy. The method described below is simple to use and much more rapid than either of the above. Its accuracy is well within all practical needs.

The velocity of combustion V_c of cordite M.D. under pressure P tons /in^2 may be represented by—

$$2\,V_c = 1{\cdot}193\,P = \mu \quad \text{.....I.}$$

NOTE.—μ is the reduction in inches per second of the diameter of a solid cord or of the radial thickness of a tube.

For simplicity of discussion consider solid cordite. The reduction of diameter in T seconds is—

$$R_d = \int_0^T \mu \,.\, dT \quad \text{.....II}$$

Let V_0 = Muzzle Velocity.
S_0 = Length of rifling in feet.
T_0 = Time of travel over S_0 in seconds.

Then with sufficient accuracy for present purposes—

$$T_0 = \frac{2\,S_0}{V_0} \quad \text{.....III}$$

Substituting from I in II we have—

$$R_d \text{ (up to the muzzle)} = \int_0^{T_0} 1{\cdot}193\,P.\,dT \quad \text{.....IV}$$

But the momentum of the shot M_0 (at the instant of leaving the muzzle) per square inch of the cross section A, is

$$\frac{M_0}{A} = \int_0^{T_0} (P-1)\,f.\,dT \quad \text{.....V}$$

which expression includes the Service factor—

$f = 0{\cdot}9 + {\cdot}008\,D$ and Hadcock's 1 ton/in^2 for friction.

From V we have

$$\int_0^{T_0} P\,dT = \frac{M_0}{Af} + T_0 \quad \text{.....VI}$$

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Substituting in IV we have

$$R_d = 1{\cdot}193 \left(\frac{M_o}{Af} + T_0 \right) \ldots\ldots\ldots\ldots\ldots\ldots \text{VII}$$

Which on substituting from III becomes

$$R_d = 1{\cdot}193 \left(\frac{M_o}{Af} + \frac{2\ S_o}{V_o} \right) \ldots\ldots\ldots\ldots\ldots\ldots \text{VIII}$$

NOTE.—The momentum M_0 is in ton units

$$\text{Thus } M_0 = \frac{W\ V_0}{2240\ g}$$

A is in square inches $= \pi\ D^{2}/_{4}$

f may be ignored for large guns, in any case it may be written conveniently

$$\frac{1}{f} = \frac{1100 - 8D}{1000}$$

Taking the older form of cordite and analysing Col. Mansell's figures we have

$$2\ V_c = 0{\cdot}29 + 1{\cdot}336\ P \ldots\ldots\ldots\ldots\ldots\ldots \text{IA}$$

and using this in the equations II, III, IV, and V, as before we obtain in place of VIII above the equation

$$R_d = 3{\cdot}25\ \frac{S_o}{V_o} + \frac{4}{3}\frac{M_o}{Af} \ldots\ldots\ldots\ldots\ldots\ldots \text{VIIIA}$$

This equation may be compared with easily accessible data, as for instance the example in Part II of Text Book of Gunnery page 142 et. seq.

$$\begin{aligned} \text{There } S_0 &= 11{\cdot}5 \text{ ft.} \\ W &= 60 \text{lbs.} \\ D &= 5 \text{ inches.} \quad A = 19{\cdot}6 \text{ in}^2 \\ V_0 &= 2080 \text{ ft/sec.} \end{aligned}$$

$$M_0 = \frac{60}{g} \cdot \frac{2080}{2240} = 1{\cdot}735 \text{ ton secs.}$$

$$\frac{1}{f} = \frac{1100 - 40}{1000} = 1{\cdot}060\ .$$

Substituting in VIII A we have

$$\begin{aligned} R_d &= 0{\cdot}0179 + 0{\cdot}1254 \\ &= 0{\cdot}1423 \end{aligned}$$

The Text Book gives 0·1420 so that the agreement is remarkably close.

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The considerations from which this result has been obtained are so simple in comparison with conventional methods that suspicion might be aroused and directed to the fundamental equation III which is obviously an approximation based on the assumption of uniform acceleration in the bore. It will be seen, however, in equation VIII that the term involving the assumption is relatively small—in the example worked out it is only ⅛ of the total so that an error of 2% in the time of travel T_0 involves an error of only 0·25% in the total determination.

Further, it is to be noticed that in determining the thickness of cordite burnt the essential governing factor is the time integral of the pressure behind the shell. Ingalls, Mansell and every other worker must use this if a linear law of burning is assumed. In the method given above the time integral of the powder pressure is obtained automatically from the momentum of the projectile which of course is the time integral of the resultant force on the shell. In deducing powder pressure from net resultant, well founded and long tried corrections are used but internal ballistics is an experimental branch of science and must involve corrections. Thus it is considered that equation VIII or VIII A properly used will give rapid results comparable in accuracy with other more complex methods.

As a refinement on the method described actual velocity curves might be compared with the parabolic curve assumed and the resultant small correction embodied in the $\frac{S_0}{V_0}$ term.

To ensure complete combustion before reaching the muzzle a multiplying factor of 0·9 might be applied or as is more usual in practice the next smaller standard size of cordite.

In conclusion, it is important to bear clearly in mind what the method given will do. It solves only a small problem in Interior Ballistics. It will not give muzzle velocities or the weight of cordite required—these are bound up with considerations of energy and expansion volumes. But given the momentum of the projectile as it leaves the bore and the approximate time of travel in the bore it will give very simply, and with sufficient accuracy for practical purposes, the thickness of cordite burnt in the bore of the gun.

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AN ERA OF SUBSTITUTION.

A HOME-MADE GUN FOR TRAINING PURPOSES.

By Major B. J. T. Ford, R.F.A. (T).

THE present war with its ever insistent call for men has raised many problems as to the most effective methods of training rapidly large numbers of soldiers.

The tremendous development of the Artillery branches of the Service has called for a higher standard of training than ever, and the great difficulty which has presented itself to Training Staffs has been the adequate education of the gunner in all branches of his work, with the limited equipment and shortness of time at the disposal of the Instructors.

It would seem to be desirable to make the training as realistic as possible in order to accustom the gunner as far as may be to the actual results of firing a gun, even although it will often prove quite impossible to give him firing practice with live shell.

For this purpose and with this object a loading machine has been suggested for use as an accessory to whatever gun is available for training.

With even the 18-pdr. Q.F. the incidents of firing are not reproduced for drill purposes without actually firing shell from the gun as—

(1) No recoil can be obtained.

(2) The drill shell complete is ejected on opening the breech, instead of the cartridge case only.

Also the supply of 18-pdr. Q.F's is extremely limited.

The Loader which has been made entirely in a Battery workshop without the aid of machinery or suitable tools supplies these deficiencies, and has the following points:—

1. It can be used in a barrack room or out of doors.
2. It can be used with either a No. 1 or No. 7 dial sight.
3. It can be traversed, elevated, depressed and layed.
4. It can be loaded in the same way as a gun.
5. The breech mechanism is similar to that of 18-pdr. Q.F.
6. The gun recoils on the firing lever being pulled.
7. The gun is run up again and on opening the breech the cartridge case is extracted automatically.
8. The gun can be equally adapted for use on a carriage and attached to a limber, if required.

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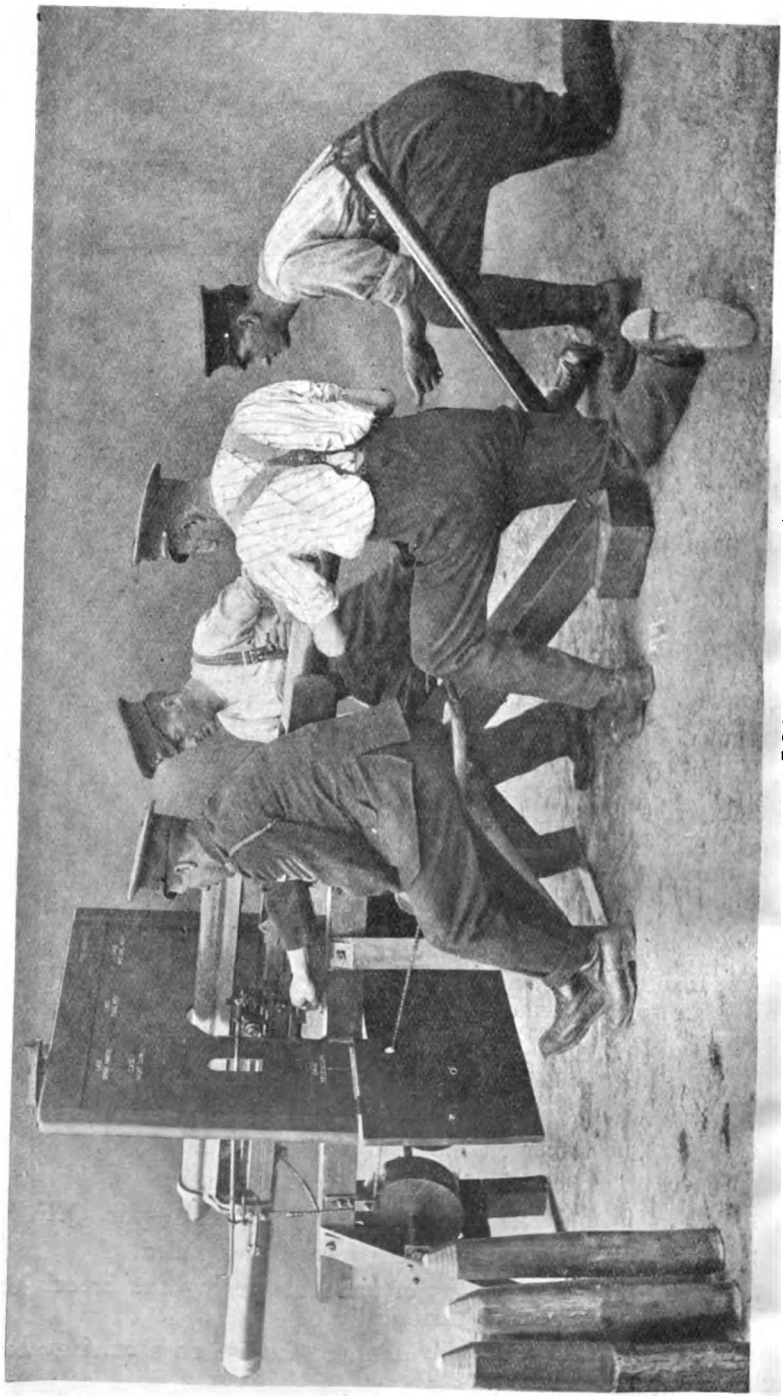

LOADING.

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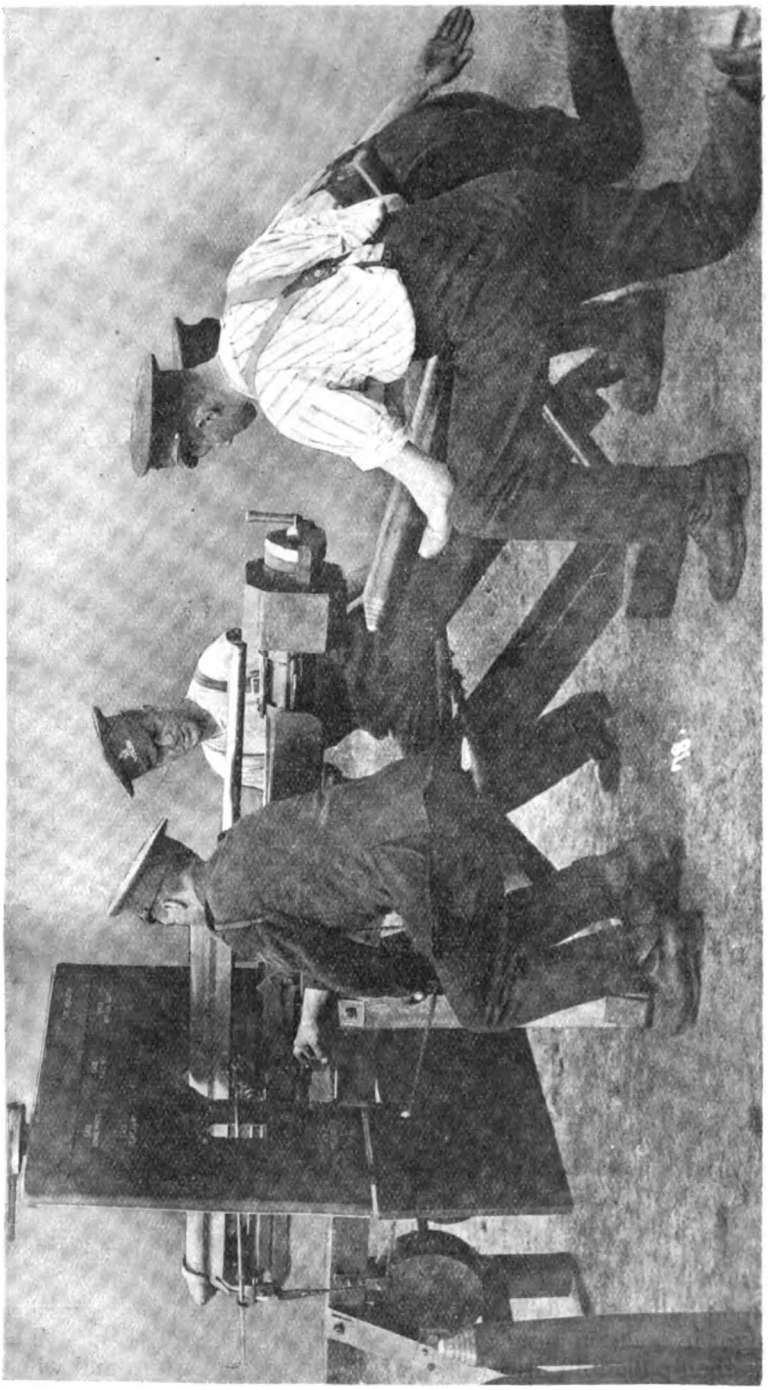

FIRED.—IT WILL BE NOTICED THAT THE GUN IS IN EXTREME RECOIL.

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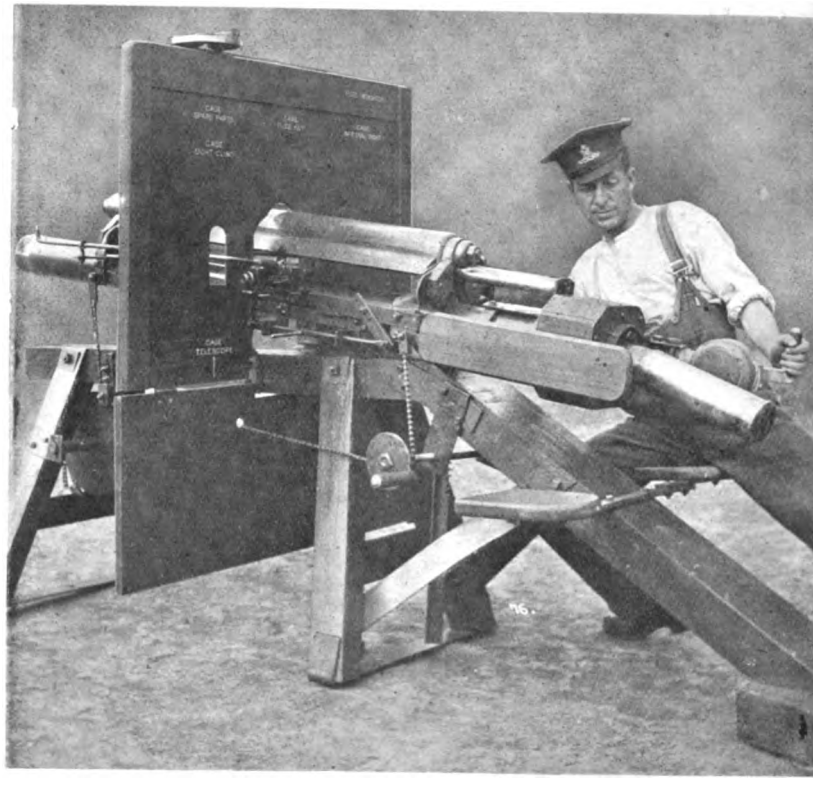

OPENING THE BREECH TO RE LOAD.

The gun is running up to the firing position.

The accompanying photographs show the loader in use.

No. 1 shows the detachment in the act of loading.

No. 2 shows the gun in recoil after firing.

No. 3 shows the gun running up and the cartridge case being extracted by opening the breech.

The piece consists of stove piping, with slides on either side, working in grooves fixed on the carrier.

The spring mechanism is contained in a dummy buffer through which runs a plunger attached to the breech of the gun.

Upon pulling the firing lever, the spring, which is in compression, is brought into action and causes the piece to run sharply back. The piece is then pulled into the firing position by means of a hand wheel operated by a spare number.

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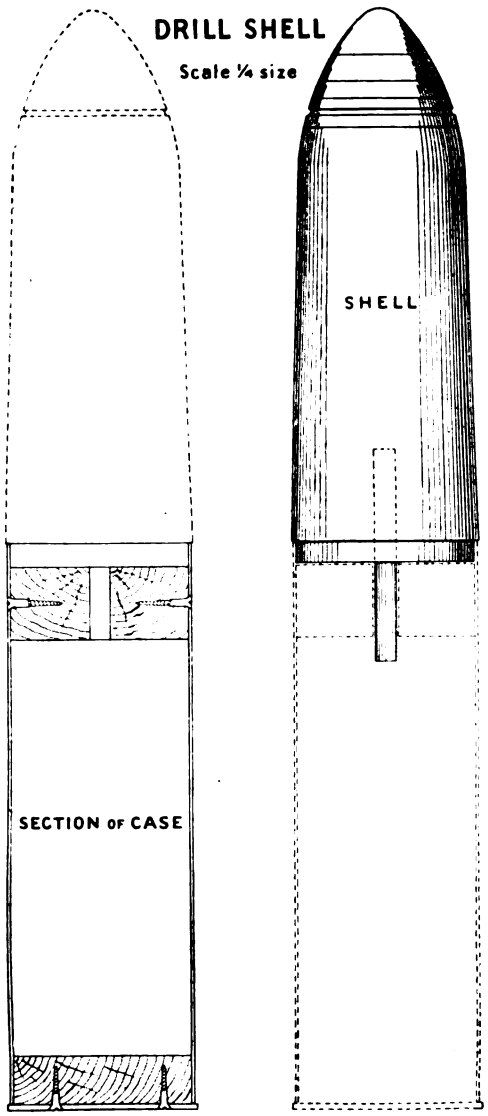

The dummy ammunition used has been locally constructed and is made in two parts fitting into each other (1) the shell (2) the cartridge case—as illustrated in small sketch.

The act of loading releases the shell from the case, and as already explained the case is ejected by opening the breech. The shell travels by its own weight up the gun and is pushed out into a tray by the next shell being loaded.

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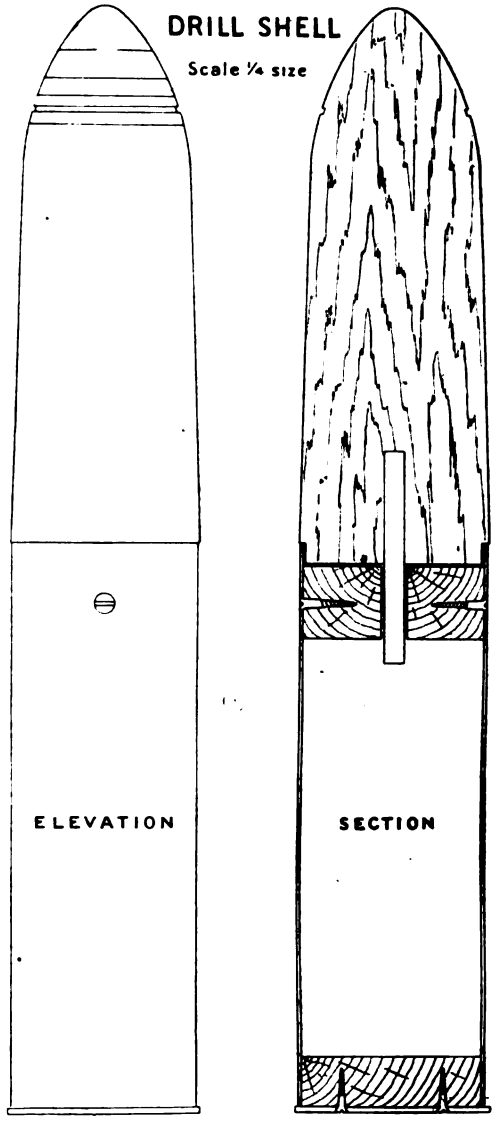

A rocking bar sight, sight clinometer and revolving range dial, all made in the battery shop are provided, so that the loader can be used for laying, or for gun drill as required.

A shield with a hinged extension is provided and on the upper portion is painted the position of the various articles carried on the 18-pdr. gun.

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The advantages claimed for this loader are:—

1. Men can be taught to load carefully and rapidly without using a gun for the purpose.

2. The men see as nearly as possible the results of firing a live shell.

3. The recoil of the gun and the sharp extraction of the shell case clearly demonstrate the need for keeping the proper positions assigned to the gun numbers.

4. These effects can be all combined with actual gun drill.

5. Wear and tear of the breech of the 18-pdr. gun itself is saved.

6. Another gun is added to training equipment.

7. The drill shells (fuzed) provided are not knocked about by being loaded into the gun but can be utilised for setting fuzes and laid on the ground while the home made shells and cases are used for actual loading purposes.

8. Its use being possible in a room enables training to be continued by day or night and in wet or fine weather.

With machinery and proper tools many improvements could of course be made in the mechanism and finish of the "loader" but the utility of such an invention would seem to be successfully demonstrated by the experience gained by those who have been trained in its use.

PRÉCIS OF REVUE MILITAIRE SUISSE.

By Captain G. de L. Landon, M.C., R.A.

June, 1917.

The Belgian Army and Neutrality.

A convincing reply by a Belgian Staff Officer to the German charge of complicity with England and France in a plan to attack Germany in August 1914. The writer cites the dispositions of the Belgian Army previous to Germany's violation of the frontier, these dispositions being such as to provide resistance to either France or Germany and quotes the "General Ideas" of the annual Staff Rides held by the Belgian General Staff for the fourteen years previous to the war. Of these six pre-supposed Germany as the adversary, seven France, and one England (1910) with the possible adherence of

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France. The schemes set to the Belgian Staff College showed a similar impartiality, and in all solutions and remarks on schemes by the General Staff a complete freedom from bias on either side always prevailed.

The German campaigns in the West.

Conclusion of article in last number. A concise account of the strategical events in the West from the end of the first battle of Ypres to the German withdrawal of March 1917, with interesting comments thereon.

The Italian theatre of operations.

Continued from last number. Deals with the operations of the Autumn of 1916.

United States Chronicle.

The military situation at the Declaration of War—First defensive measures—Modification of original plan for increasing the effectives—Volunteers and Conscripts—The formation and training of the fresh units.

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The Italian theatre of operations.

Continuation of previous articles. The present article deals with the operations in the spring of this year, that is—

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The Carso offensive between May 23rd and June 8th whereby the Italians captured Boscomalo, San Giovanni, Flondar, and Medeazza.

Notes on the Machine Gun.

A technical article dealing with the employment of the machine gun for oblique traversing fire, and searching and traversing over large areas.

The Russian campaigns of 1914-1916.

A resumé of the campaigns in E. Europe with remarks on the probable plans of the opposing generals. The author's principle sources of information are English publications viz: International Military Digest, and Twelve Months of War on the Eastern Front from the Journal of the United Services Institution of India.

United States Chronicle.

A summary of the U.S. Military Service Act with interesting figures as to the strength and organization of the Regular Army, Militia, and 1st Batch of Conscripts as communicated to the Press by the American War Minister.

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THE ARMIES OF THE FRENCH REVOLUTION.

A Lecture delivered at the Royal Artillery Institution, Wednesday, 24th October, 1917.

BY BRIG.-GENL. F. G. STONE, C.M.G., *psc.*

Maj.-Genl. W. F. Cleeve, C.B., R.A.,

Commandant Royal Military Academy, in the Chair.

THE CHAIRMAN: It is my pleasure to introduce to you the Lecturer, General Stone, who is going to deliver a very interesting historical lecture, and I would ask him to kindly begin.

BRIG.-GENL. STONE: General Cleeve, Ladies and Gentlemen: The subject of my lecture is "The Armies of the French Revolution," but the whole of the time I was preparing it I was not thinking so much of France as of Russia. I am not going to draw any parallels in my lecture or allude to Russia in any way; but if you will keep your thoughts constantly upon what has been occurring, and what is occurring and what is likely to occur in Russia, I think you will find my lecture more interesting and *apropos* at the present time than you would otherwise. One great difference between the situation in Russia and in France at the time of the French Revolution appears to me to be that in Russia and in the Russian Army they are further handicapped than the French Armies were by the insidious and extremely powerful propoganda on the part of Germany, inciting the men, both in the Army and in the Navy, to acts of mutiny, and also spreading the false information that France and Great Britain have left Russia to her fate, and that the whole of the time France and Great Britain have been making no effort whatever to win the war, but have been leaving the whole of the brunt to be borne by Russia. The propaganda, I believe, has been extremely successful. Of course there was nothing of that kind in the French Armies; it was pure social disintegration. I have just been reading in the evening paper a communication from Russia which is that the Petrograd Council of Workmen's and Soldiers' Delegates have passed a resolution demanding "that all power should pass into the hands of the Council of Workmen's and Soldiers' Delegates, and instructs the Executive Committee to propose an armistice to all the nations." You will find that there is a very strong parallel between the Petrograd Council of Workmen's and Soldiers' Delegates and similar organisations in Paris.

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The French Revolution may be said to have commenced on June 17th, 1789, on which date the Third Estate of the States General (summoned by Louis XVI, after an interval of 175 years since the last meeting) declared itself to be the National Assembly, and passed its first "decree," proclaiming "all existing taxes illegal, as not sanctioned by the consent of the people." In its initiation, the Revolution was an honest, if somewhat confused effort, to establish a constitutional form of government with the King as head of the State: It then proceeded to pass through various phases of degradation, which culminated in the Terror in 1793, after which matters improved under the Directory to a certain extent, and finally anarchy and chaos were abruptly brought to an end by the *coup d'état* of Napoleon Bonaparte in November, 1799, which under the skilful management of his gifted brother Lucien, made Napoleon the military dictator of France. In order to understand the military situation in all its bearings, from the beginning of the Revolution up to the time when the Revolutionary Armies had achieved cohesion, discipline and efficiency, it is necessary to assimilate the political and social atmosphere of the period during which these armies were created.

It must be understood that Louis XVI summoned the meeting of the Three Estates as a last desperate measure to save France from national bankruptcy and disintegration, the inevitable results of generations of misgovernment. Prior to the meeting of the Three Estates at Versailles, in 1789, a sort of agenda had been compiled from the replies given throughout the country to the various questions which had been submitted on official forms, termed "cahiers"; these were practically statements of grievances, they show what was amiss in France, and what reforms were most ardently desired by Frenchmen. There was a general consensus of objection to despotic government, and all three Estates desired a constitution, which, however, differed in its definition according to whether the demand was formulated by the First and Second Estates, i.e. the nobles and clergy, or by the Third Estate, which preferred to ignore the old institutions of France, as never expressly approved by the people, and so leave the legislature free to mould the constitution to meet their wishes. One cannot fail to be struck by the fact that nearly every reform which has taken place, or for which statesmen are even now working, was included in the "cahiers" of the Third Estate, either specifically or by inference, the ideals of good government were all there, but the people being without political experience or constructive training, made the usual mistake of believing that all abuses could be rectified in a moment by statesmanlike legislation. Many fruitful ideas are to be found in "cahiers," not only of the Third Estate, but also of the nobles and clergy; for the spirit of improvement was widely diffused, and the love of mankind which was on the lips of all, was in the hearts of many. There was, in fact, a general revolt against the abuses of despotic government; little did they guess who had wilted under the sting of despotism, how soon the avalanche of revolution, gathering speed, would crush them under the far worse torment of anarchy.

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Side by side with the beginning of the social and political revolution, was the general state of disorder throughout the country caused by the scarcity of bread following on the bad harvest of 1788: the measures taken by Necker served only to make things go from bad to worse. The Government offered premiums to importers of corn, and bought corn itself, corn and flour were only allowed to be sold in the markets. These measures caused alarm, hampered traffic, and deepened the distress they were meant to relieve. In a country were the government was so much despised and the elements of insurrection so plentiful, violent outbreaks were sure to follow. They began in January 1789, and as the civil and military authorities were afraid to do their duty, they multiplied and became more outrageous. Thus set in the period of disorder caused by scarcity, and of scarcity rendered more acute by disorder, which lasted with intervals for ten years. If constructive statesmanship was lacking in the National Assembly in its infancy, it was not surprising; but that the King and the Government should show an equal inability (or was it lack of desire?) to lead the great political forces now let loose for the first time, into channels of usefulness to the State, showed a lack of foresight which was destined to bring about a cataclysmal *dénouement* which was not even dreamed of at the moment by the most rabid revolutionary in France. Owing to their suspicion of the *bona fides* of Louis, and incensed at the discourtesy with which they had been treated, the deputies of the Third Estate, meeting in the Tennis Court, bound themselves by oath (with one exception) not to allow their assembly to be dissolved until the constitution had been established.

On June 23rd Louis held a royal session, the only effect of which was to bring into sharp contrast the intentions of the King and the aspirations of the deputies. The King absolutely refused to agree to the merging of the Three Estates into a National Assembly, insisting that they should carry out their deliberations separately, and pass their resolutions as separate consultative bodies. The Third Estate deputies were unanimous in insisting upon the fusion of the three estates and on the recognition by the King and Government of the National Assembly as a legislative body: every crisis brought over larger numbers from the First and Second Estates to the views of the Third Estate, and towards the end of June the King accepted defeat at the hands of the National Assembly; but a considerable number of the nobility and clergy deplored the surrender of privilege and fully intended to seize the first opportunity to recover the independence of their orders

On June 6th the National Assembly appointed the first committee of the Constitution.

Meanwhile the forces of disorder in Paris had been coming to a head. The Duke of Orleans had been busy organising a conspiracy to supplant Louis on the throne: he had made his palace a rendevous for the most reckless politicians and dissipated characters in the city, and set to work deliberately to seduce the loyalty of the Gardes Françaises, which together with the Gardes Suisses formed the military force at the disposal of the Government for promptly reinforcing

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the police in case of riots or disturbances. After many acts of insubordination, a secret society was discovered in the Gardes Françaises, whose members had bound themselves to obey no orders directed against the National Assembly. Several of the culprits were imprisoned, the mob released the prisoners and many dragoons and hussars, who had been called out to suppress the riot, fraternised with the mob. The Marshal de Broglie in the meantime had collected a considerable force of troops at Versailles, avowedly for the protection of the Royal Family. The Assembly seeing in these preparations a menace against their own body, remonstrated, and asked that the troops might be withdrawn: the argument was brought to an abrupt conclusion by the King dismissing Necker, and ordering him to quit the kingdom; his most trusted colleagues were dismissed at the same time, and the Baron de Breteuil, a friend of the Queen, succeeded Necker as Chief Minister. Thus the party hostile to the National Assembly prevailed with the King. On July 12th the dismissal of Necker became known, and memorable riots commenced; on the 14th the Invalides and the Bastille were taken possession of by the mob. During these events, the mob was strongly reinforced by numerous deserters from the Gardes Françaises, and practically no steps were actually taken to employ the military force available to quell the riot, the private soldiers had been debauched by the democrats and the chiefs were irresolute. A civic guard of sixty battalions was organised to restore order, and by degrees an improvement was effected. On July 15th, the King realising that the Army could not be trusted, capitulated to the demands of the Assembly and recalled Necker, and withdrew the troops. Those who had been most active in procuring the dismissal of Necker, now felt that their own position was unsafe, and the Comte d'Artois, Prince de Condé, Prince de Conti, Duc de Bourbon and Marshal de Broglie accompanied by many others, went into exile and thus formed the vanguard of the *emigrés* who were to cause so much trouble to France. The Marquis de Lafayette, a liberal nobleman, who had seen service in the American War, was appointed to organise the new civic guard under the title of the National Guard; it was a volunteer organisation, in which the Gardes Françaises was incorporated as a paid battalion.

The influence of the Paris insurrection was now making itself felt throughout the country, insubordination and chaos were rapidly bringing about a state of pure anarchy. The incompetence and futility of the National Guard was every day becoming more evident; the reasonable and sometimes lofty ideals with which the meeting of the Three Estates had been inaugurated, were wholly submerged in the clashing interests of parties greedy for power. Administration was brought into a hopeless impasse by the various committees which were supposed to direct it in the several departments.

On 5th October the Paris mob proceeded to Versailles, invaded the King's Palace, attempted to murder the Queen, and returned to Paris the next day accompanied by the King and the National Guard. The Assembly decided that it must at the same time remove its own headquarters to Paris. It may be said that on 14th July Louis lost his crown, but on October 6th he lost his liberty and virtually became

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a prisoner in the Tuilleries: the National Assembly was itself practically in the clutches of the Paris mob.

At the end of 1789 Federations of the National Guards from neighbouring districts inaugurated the custom of meeting together to swear mutual friendship and obedience to the decrees of the Assembly. The friends of the Revolution saw the value of these meetings; and the municipality of Paris proposed, and the Assembly decreed on June 5th, 1790, a general federation of the whole of France to take place on the anniversary of the capture of the Bastille.

Accordingly on July 14th in the presence of the King, the Queen, the National Assembly and an innumerable concourse of spectators, including 14,000 of the National Guard and 11,000 representatives of the Army, Tallyrand, Bishop of Autun, assisted by 200 priests, celebrated Mass at an altar raised in the midst of the immense amphitheatre, which had been specially erected for the occasion.

The spectacle was not without the desired effect in promoting a sort of revolutionary freemasonry. The federations completed the dissolution of the Army by bringing the men of the regular forces under the direct influence of the revolutionary clubs, and soldiers' committees were formed in every regiment. Garrisons sent deputations to each other and to the National Assembly; officers were put under restraint by their men; hundreds of officers emigrated and thousands of men deserted; looting and license of all kinds became rife, an open mutiny broke out in Nancy which was ultimately put down after great loss of life, the mutinous soldiers being backed up by the mob which literally took possession of the city.

It was most significant of the future trend of events, that Danton and Marat and others, who desired to prolong anarchy in order to make the revolution more thorough, clamoured against the Minister of War, who had approved of the court-martial sentences against the mutineers, and even against the Assembly itself for its concurrence in the necessary steps which had been taken to restore discipline. And their clamour was not in vain—the mutineers condemned to the galleys were amnestied!

The state of the Navy was a counterpart of that of the Army.

On June 20th, 1791, Louis tried to escape to Metz, but was stopped at Varennes on the following day and brought back a prisoner to Paris.

On 14th September, 1791, the Constitution was voted. The control of the armed forces was withdrawn from the King's authority. The National Guard, 4,000,000 men, became the embodiment of armed anarchy. Finally the Constitution was overthrown within a twelvemonth by a motion of Robespierre's that the members of the Assembly should be incapable of sitting in the next Legislature. All the dearly bought experience of the last two years was thrown away and the success of anarchy assured.

Having thus outlined the environment in which the Armies of the Revolution had come into existence, it will be necessary to take a brief survey of the conditions under which the Royalist Army had been organised and administered prior to the Revolution, in order to

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understand how years of jobbery, stupidity and maladministration, had already prepared the soil for the seed of revolution.

Small armies and long service were the rule in France as in Western Europe generally, since the sixteenth century; professional skill and discipline being valued more than numbers. As the number of recruits required each year was not great, voluntary enlistment was in force for the regular army, the ballot being reserved for the militia. The conditions of life in the regular army were such, however, that it was usually sheer necessity that drove recruits into the ranks, which were filled in consequence with the needy, thriftless and dissolute: there was no possibility of gaining a commission from the ranks.

On the other hand, the still powerful prejudice handed down from the age of chivalry, that arms are the true profession of a gentleman, disposed the nobles of every land to accept commissions as officers—from their own sovereign if possible, but failing that, from any other Christian sovereign with whom he was not at war: even up to the date of the Revolution, the calling of a soldier of fortune was not thought dishonourable. It was therefore difficult for a man of the middle class to become an officer, and the conditions under which the private soldier lived, were such as to make it a rare event for a man of this class to enlist, and the middle class in the eighteenth century therefore remained purely unmilitary. In the reign of Louis XVI, France maintained a standing army of about 170,000; of these, about one sixth were foreigners (Prussia, with one third the population maintained an equal number). In order to satisfy the nobility, the number of officers had risen out of all proportion to the numbers of the rank and file. At the beginning of the Revolution there were 966 generals and 1918 staff officers, i.e. one general for every 157 privates. Mere boys were promoted to comparatively high rank, and the Duc de Choiseul raised quite an outcry in aristocratic society, by refusing to allow any more colonels of sixteen years of age! Marshal de Broglié declared that all the officers, from sub-lieutenant to lieutenant-general, were totally ignorant of their profession. Desertion was common. In the Seven Years War, France had yielded the first place among military states to Prussia. Yet there was some excellent individual stuff in the Royal Army, as was proved by the number, both of privates and of officers, who rose to fame in the wars of the Republic and of the Empire. Out of 24 Marshals of France created by Napoleon, 8 had been officers, and 10 had been privates under Louis XVI. Such, therefore, was the army which ceased to be a Royal Army under the control of the King upon the voting of the Constitution of 14th September, 1791.

We pass now to the historic events which precipitated France into a war, which, originating in the necessity of defending the Revolution against external foes who were allied with the Royalist cause, was the means of forging that formidable military weapon which later on, in the hands of Napoleon, was destined to humble Prussia in the dust, and bring the rest of Europe under a yoke of military domination, from which she was not set free until 1914.

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The abolition of feudal rights by the French Constituent Assembly was the subject of vehement protest on the part of certain Electors, Princes, Knightly Orders and Knights of the Holy Roman Empire, who held lands in Alsace. They were offered monetary compensation by France, which most of them refused to accept. In December, 1791, the Emperor Leopold of Austria had sent a strongly worded protest against the transference of the imperial territories in Alsace. He had offered secret aid and an asylum to the French Royal Family at the time of the flight to Varennes; and further, in July, 1791, he had issued a circular from Padua, to the monarchs of Europe, calling on them to aid in freeing the French king from popular restraint. This circular had led to a conference between the Emperor and the King of Prussia at Pillnitz in August. It was there settled that, since the preservation of the French monarchy was an object of universal interest, an invitation should be sent to the other European Powers, calling on them to aid in restoring the King of France to his rightful position; but at the same time safeguarding the liberties of the French people. The object of Leopold in issuing this circular was to intimidate the French people, he fully realised that none of the other Powers, except Prussia, were likely to intervene. On March 1st, 1792, Leopold died. On the 20th April France declared war on the "King of Hungary and Bohemia" (i.e. Austria), and Frederick William of Prussia, notwithstanding the strong French sympathies of a powerful party in Prussia, refused to renounce his alliance with Austria, as he had been urged to do by the French Royalists and Girondins, and immediately took measures to support his ally.

Thus began a war which raged with scarcely any intermission for twenty-three years.

The first Armies of the Revolution had been located by a decree of 14th December, 1791, in three groups, known respectively as the Armies of the North, Centre and Rhine. and commanded respectively by Rochambeau, Lafayette and Luckner.

The rank and file of these armies had been raised by the old Monarchy, but the personnel of the officers had undergone profound modification. The greater part of the old staff of the army had retired or emigrated, but the artillery and engineers remained. The inadequate numbers available to deal with a possible invasion of France was brought home to the National Assembly at the time of the King's flight to Varennes, when the possibility of such an event assumed an aspect of imminent probability. On August 17th, 1791, the Assembly called for 101,000 volunteers which were formed into 169 battalions By September 25th only 60 battalions had any sort of organisation, as might have been expected, and in these the greatest disorder and insubordination reigned supreme; their march through France was one great plundering expedition. The War Minister was the Comte de Narbonne; it was due to him that France had any army at all, or the volunteers any organisation: in spite of this the Assembly did its best to thwart him at every turn. Two decrees were issued which were well calculated to cripple the volunteer organisation at the outset: one was to give the right to every

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volunteer to return home at the end of a campaign (i.e. December 1st, when armies were supposed to go into winter quarters), after giving two months' notice: The other allowed volunteers to choose their own officers. In vain did Narbonne urge that the nomination of officers should be left in the hands of the military authorities, and that the volunteers should be brigaded with regular troops; the Assembly refused to hear of either of these measures. But fortunately for France, Lafayette, on his own initiative took the latter step in the Army of the Centre, so that when the crisis came the volunteers of the Army of the Centre were something better than a mere rabble and thanks to the backbone of regulars in each brigade were able to oppose some sort of resistance to the enemy. In course of time other commanders followed the lead of Lafayette.

Thus at the commencement of 1792, France was preparing to enter into war with an army composed partly of regular soldiers of the old regime, whose discipline had been debauched by three years of licensed insubordination, and whose officers were viewed with suspicion by their men, or were old non-commissioned officers, as yet untried in the role of commissioned officer, and partly of volunteers, who as yet had little organisation and less discipline; with a general staff whose personnel was constantly changing at each fresh burst of jealousy and suspicion; with fortresses long neglected, badly armed and ill-provisioned; with no system of transport and supply; and with a War Office which had still all the faults of the old regime, its lack of method and absence of responsibility, added to which was a complete lack of continuity due to the meteoric rate at which one Minister of War succeeded another—six in six months! Further, the plans of these ephermeral Ministers of War, whether good or bad were impartially and contantly overridden by an Assembly in which passion stood for statesmanship, and hypocrisy for patriotism.

Though war had been declared on 20th April, 1792, neither side was ready; mobilisation proceeded slowly and active hostilities did not break out until much later. In the meantime every conceivable blunder was committed by the totally inexperienced War Minister, Servan, who received his instructions from an Assembly dominated by passion and sublimely ignorant of the art of war.

Lafayette was now placed in command of the left from Dunkirk to Montmédy, with 43,000 men. The Centre, now under Luckner, 17,000 strong, watched the roads which led into France by the Moselle, from Montmedy to the Vosges, with Hd. Qrs. at Metz. The Army of the Rhine under Biron composed the right wing; its function was to close the passes between Landau and Bitsche, and the great gap between the Vosges and the Jura, known as the Gate of Burgundy.

The Army of the Reserve, composed of the depôts of cavalry regiments and infantry battalions, and of the very unreliable volunteers of 1792 was collected at Soissons: it was an unorganised rabble, lacking everything, even arms and clothing, since the Government factories had completely broken down. It was fortunate for France that the Army of the Reserve never had to be taken into

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action; and that the ill concerted alliance of Austria and Prussia recoiled before accepting any trial of strength. During the extraordinarily ill-conducted campaign of the Allies, Lafayette was replaced by Dumouriez in command of the Northern Army, and Luckner was replaced by Kellerman in command of the Army of the Centre. After some reverses to the French arms, Dumouriez and Kellerman ultimately defeated the Prussians under Brunswick, at Valmy on September 20th; the French troops which achieved this success were not the newly raised revolutionary troops, but those of the old Royal Army. The Prussians were much discouraged by their defeat, and the French proportionately elated, but the French armies could not yet be trusted to assume the offensive, and both sides were equally ready to negotiate. On September 21st Convention declared France a Republic

The Prussians began to retreat on September 30th, but the pursuit was not commenced until October 5th with a view to detaching Prussia from the Austrian alliance, by showing her every possible consideration while negotiations to that effect were being pressed. Verdun was evacuated by the Prussians on October 14th, and Longwy on the 23rd. Finally the Prussian army recrossed the frontier with only 10,000 effectives, out of an army of 42,000 which had entered France two months before. In the meantime the Army of the Rhine had captured Mainz, Frankfurt had fallen, and the Prussians withdrawn to Coblenz.

On October 5th Dumouriez had handed over the pursuit of the Prussians to Kellerman and proceeded to Paris, where it was decided by the Convention that he should invade the Austrian Netherlands by way of Mons. Dumouriez was strongly supported by Danton and the Jacobins, but the new War Minister, Pache, hated him, and proceeded at once to handicap him by instituting the notorious Directoire des Achats to control the purchase of all supplies and incidentally to fill the pockets of the greedy civilians engaged in what was euphemistically termed the supply service for the army. The Commissary-General, Doumercq, who had achieved such wonders in the Valmy campaign, was dismissed, and Malus, Dumouriez's commissariat staff officer was arrested. Thus handicapped, Dumouriez started on the autumn campaign to release the Netherlands from Austrian dominion. He attacked the Austrians 13,200 strong, in a position near Jemappes, which covered Mons from the north, and after a stubborn fight completely defeated them, but was unable to follow up his success by pursuing them to Brussels, owing to the disorganised condition of his wearied troops, and D'Harvilk, who commanded a column in support near Namur, lacked the nerve to launch it in pursuit.

In this battle the Austrians lost 4,000 killed, wounded and deserters, out of a total of 13,200. The French success was entirely due to their overwhelming numbers, and the energy and courage displayed by Dumouriez and other general officers. The old battalions of the regular army fought well, and three battalions of the volunteers of 1791 showed considerable pluck and pertinacity. The artillery was twice as strong as the Austrian artillery and was admirably

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handled. But the volunteers of 1792 again and again refused to advance to the attack, and when they had been induced to do so, broke at the first sign of resistance.

This was the first real victory gained by the Republican arms in the field after a serious fight, and the whole of the French nation was dazzled. Europe was amazed at the vitality of France. Belgium was rapidly evacuated by the Austrians; Ypres, Furnes, Nieuport, Bruges, Tournai, Ghent, Antwerp, Charleroi and Namur surrendered to the French, and Dumouriez could have rounded up and annihilated the remains of the Austrian army if he had not been crippled by the breakdown of his commissariat, which as mentioned above, had been utterly disorganised by Pache, the War Minister. Added to this the evil effects of the Volunteer Regulations of 1791 were being felt to the full, and the army, which at the end of October had numbered 100,000, was reduced at the end of December to 45,000.

Custine, moreover, had been compelled to fall back on the Rhine, and French administration in the Rhine valley had irritated the inhabitants to a dangerous degree. On December 15th, 1792, a decree of the Assembly established French revolutionary institutions throughout the occupied territory in Belgium; this unwise and arbitrary step put the finishing touch to the dissatisfaction of the Belgians, already irritated at the unavoidable exactions levied on them, and exasperated at the wholesale plundering and lawlessness of the French troops. On January 26th, 1793, the finishing touch was put to the strained situation by Danton's order to incorporate the Belgian troops in the French Army. On January 21st Louis was executed. On February 1st war was declared by France on England and Holland, and an ultimatum addressed to Spain in March. Dumouriez's plan for the invasion of Holland was put into execution, and resulted in the capitulation of Breda on February 26th and of Gerttruydenberg on March 1st, followed on March 1st by the defeat of the French on the River Roer by the Austrians under Coburg.

Dumouriez was recalled to Belgium by the Convention on March 8th, and was horrified to see the state of demoralisation into which the army had fallen in his absence; it was panic-stricken as well as demoralised, and the Belgium population was on the verge of revolt. He quickly restored order both in the army and among the population by wise and statesmanlike measures and the immedate influence of his own personality.

Meanwhile the Government in Paris had declared the country in danger and called for fresh volunteers. On March 19th the Austrians defeated Dumouriez at Neerwinden, partly owing to the hopeless inefficiency of the volunteers under Miranda, and partly owing to bad generalship on the part of Dumouriez. Coburg, however, had not grasped the extent of demoralisation to which the French Army was reduced and promised not to attack again if Dumouriez agreed to evacuate Brussels, which he did on March 24th.

Dumouriez for some time had been feeling more and more dissatisfied with his position in reference to the Republican Government, and now after having served France well in the hour of her greatest need, after vainly attempting to persuade his army to go over

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to the enemy, went over himself with a handful of generals and staff officers, and a few hussars to the Austrian Head Quarters.

In the meantime three deputies from the Convention had arrived in the Rhine Valley on 31st December, and the annexation of Mainz was proclaimed on 14th February, 1793. On April 14th Mainz was invested by the Prussians, and capitulated on July 23rd. The effect of this on the armies of the Moselle and Rhine was most serious.

On August 10th the Great Committee of Public Safety deprived all officers of noble birth of their commissions, and a *levée en masse* was decreed.

To return to the north—Dumouriez was suceeded by Dampierre, who was killed in action on May 7th, and was replaced by Lamarche, who, on May 23rd, was driven back to Bouchain by Coburg. He was superseded by Custine, who introduced a new spirit of discipline, but fell foul of the civil authorities, and was recalled to Paris, where he was guillotined on August 28th. The command of the Army of the North devolved on Kilmaine, an Irishman, who however proved no more successful than his predecessors, and Valenciennes was taken by the Allies on July 26th, three days after the capitulation of Mainz. On August 9th Kilmaine was superseded by Houchard. On August 24th the Army of the Rhine was driven back to the lines of Weisenburg by Warmser, and the Commissioners deprived Beauharnais of his command, appointing Carlens, and subsequently Landremont in succession, both being mere ciphers in the hands of the Commissioners, who really held the command. Indeed during this period of flux in supreme command of the armies, the Commissioners supplied the only continuity of ideas and aims in military affairs in the field.

In August of 1793 the road to Paris was open to Coburg's cavalry, which could have entered the capital in four days. The English fleet held Toulon; Marseilles and Lyons had risen against the Government, and the situation in La Vendée was most serious. But the greed of the Allies each to secure their own share of the spoil, saved France. By September, however, Carnot's strategy was beginning to take shape. Houchard was superseded by Jourdain in command of the Army of the North. Maubeuge was relieved October 15th, and the siege raised October 17th.

We must now glance at the doings of the Army of the South under Montesquieu, which had been entrusted in 1792 with the task of securing the neutrality of Switzerland, justly incensed by the massacre of the Swiss Guards; and secondly, with the operations against the Sardinians. In July and August 1793 the Sardinians crossed the passes and entered Savoy, while the French were preoccupied with the English occupation of Toulon, and the insurrections in Lyons and Marseilles. In September Kellerman drove them back (i.e. the Sardinians) to the Mont Cenis Pass. Spain had declared war on France after the execution of the King; she was quite as unprepared for war as France. In 1793 inconclusive operations took place between the Spaniards and the French: the French commanders succeeded each other with the usual rapidity, and the army was in a state of utter demoralisation. Luckily for the French, the

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enterprising Spanish general, Curo, was held fast by order from Madrid and could make no forward movement. At last the French were able to assume the offensive and attempted the passage of the Bidassoa in August and September, but without success: the net result of the year's fighting was that the Eastern Army just managed to cover St. Jean-Pied-de-Port and Bayonne; while the Western Army remained on the defensive in Navarre and Guipuscoa.

As mentioned above Carnot's influence began to make itself felt in army administration and military policy by the autumn of 1793: the association of this conscientious reformer and splendid organiser with the criminals of the Red Terror, who ruled France from July 10th, 1793, was as remarkable, as it was beneficial, from the point of view of the efficiency of the armies. On July 13th Marat was assassinated. On Aug. 11th the Hébertists (the extreme anarchical wing of the Convention) proposed, through the representatives of the provincial communes, who had come to Paris to celebrate the fête of the Constitution the previous day, that there should be a *levée en masse* of the people of France. The proposal was a purely political manœuvre to get rid of the moderates; it appealed to sentiment and wore a spurious air of patriotism, but if agreed to, it was clear that it would throw the whole organisation and administration of the country into chaos, and would produce paralysis at the War Office, which could neither feed, arm, clothe, house or officer such mobs as would be collected. Nothing in Danton's career stands so conspicuously to his credit as the way in which he handled this critical situation: he identfied himself with the cry for the leveé, thus disarming the Hébertist faction, but at the same time pointed out the folly of making the leveé universal. "Il faut mourir pour la patrie, mais il faut mourrir utilement." Only men between the ages of 18 and 25 were called out, which resulted in an addition of 450,000 men to the army, and was practically the first step towards national military service.

The insurrection of Toulon, July 1793, which ended in an invitation to the British Fleet to occupy the town, was the climax to the disasters of this period, and was the signal for the outburst of revolutionary activity to which reference has been made above, and for the ultimate triumph of the Hébertists over the moderates, the decline of Danton's influence, and the inauguration of the period of official murders known as the Red Terror.

On October 10th St. Just, a young and violent fanatic of great determination of character, proposed that "the Government be revolutionary until the peace": thus overriding the Constitution, and permanently usurping the Government to the Committee of Public Safety.

Simultaneously came the capture of Lyons by the Republican forces, followed by wholesale massacres. In December Toulon was taken by the Republican forces and further massacres enacted: but the termination of the campaign in La Vendeé marked the climax in atrocities perpetrated by the Terrorist Government in the name of liberty.

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On October 16th Marie Antoinette was executed, and during the same month the leading Girondists were either executed or committed suicide: the year closed with the bloodiest record of revolutionary civil government which the world has ever known, at the same time as the military outlook began to look more hopeful.

Before discussing the improvement in the military situation and the condition of the armies in 1794, it will be well to take a brief glimpse at the political events which crowded on each other during the first seven months of that year.

It had become plain to all thinking men that the reign of anarchy, synonymous with Hébertism, could not continue indefinitely. Danton's efforts to reform the Government were supported by Robespierre from interested motives, and not from conviction. Christianity was abjured by the Archbishop of Paris (Gobel), and many leading ecclesiastics; the churches were turned into "Temples of Reason." The strength of the Committee of Public Safety was firmly established in the provinces, by the replacement of the local authorities by *agents nationaux* appointed by the Committee, and by the establishment of travelling inspectors known as "*Représentants en mission*," who corresponded regularly with the Committee. Robespierre vacillated between support of the Dantonists and of the Hébertists, being unable to decide at which he should strike first. Finally, on March 17th the leading Hébertists were arrested, and on 24th executed. These executions were followed on April 5th by the execution of Danton. Robespierre for the moment appeared to be supreme: St. Just proposed a dictatorship. Violent revulsion of feeling against Robespierre due to general distrust, followed by his execution, together with his confederates on July 28th. This ended the Terror: the Commune of Paris was abolished, and the Committee of Public Safety reconstructed. Turning from this bloody chaos of misgovernment and murder, we find that under Carnot's businesslike regime, a steady improvement was effected during the same period in army organisation and administration. The decree of February, 1794, laid down that only members of the Commission des Subsistances should be allowed to make requisitions. This commission summoned to Paris representatives from the provincial municipalities, and carefully explained its plans and methods. In consequence of this, and of the prompt payment which ensued, no further difficulties were found in revictualling the Army. The question of arms, ammunition and equipment for the swollen military establishments, was dealt with somewhat on the same lines as were adopted by Mr. Lloyd George in this country. Nine great factories were established in Paris which turned out daily a thousand muskets. Four foundries were established in the Ardennes by Clonet, Professor of Chemistry at Mezieres, and these, together with those in Paris, turned out 20,000 guns a year of various calibre. A new system of manufacturing powder was invented at Grenelle, and the factory there turned out 30,000 lbs. a day. Fourcroy invented a new way of treating steel which enormously expedited the output of swords and bayonets. In strategy and tactics a bold offensive was inculcated; mobility was the order of the day, and the defeat of the enemy's armies in the field

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was to supersede the old fashion of besieging fortified places—these could be reduced at leisure after the battle was won The attack was to be made by whole columns at deploying distance, thus taking full advantage of the natural élan and superior intelligence of the French soldier and placing at a discount his lack of steadiness in line formation. Clouds of skirmishers covered the centre and flanks of attacking columns and engaged the enemy, the battalion columns supplying the superior weight necessary to crush the enemy at the vital point. The objective was no longer the enemy's flank, but more often his centre, whereby his force might be split in two and one half surrounded and annihilated. The Artillery was still used to open the battle and to support the advance of the infantry, but it was being used more and more in heavy masses. The duty of the cavalry was to break through the enemy's cavalry and infantry, it was usually handled with great boldness.

Danton's maxim "*l'audace et toujours l'audace*" was the guiding principle of the new strategy and tactics. By June 1794, Carnot's great scheme was in working order. A new army of 100,000 men was formed, and called the Army of the Sambre and Meuse, it consisted of 45,000 men from the Army of the Moselle under Jourdan, together with 55,000 from the Army of the Ardennes, which were now placed under his command: to this was subsequently added the supreme command of the Army of the North, thus giving to the operations the benefit of a single guiding hand to ensure intelligent and complete co-ordination. After some successes in the North which included the recapture of Ypres, Jourdan received a temporary check at Charleroi owing to his failure to carry out the principles of the new strategy and fight the Austrians in the field with superior force, instead of laying siege to the town. This was a temporary check only, and after doing what he should have done at first, viz. fighting and beating the enemy in the field, Charleroi surrendered a week after. Immediately after this, Coburg arrived with 70,000 men to relieve Charleroi, but was met at Fleurus by Jourdan with 80,000 men—and a captive balloon! The Austrian artillery was very accurate and well handled in the ensuing battle which commenced at 3 a.m. on June 25th; at midday the French left was driven in. But Kléber managed to pull things together on the left, and at 6 p.m. Jourdan threw all his reserves into the fight and completely routed the enemy. The Allies lost 8,000 in this battle, which was a victory of the first order for the French arms. Its consequences were far-reaching. In France it sounded the death knell of the Terror, and indirectly contributed to the fall of Robespierre. Its effect on the war was immediate. The Allies were each desirous of protecting their own communications. The English thought only of covering Holland, the Austrians of reaching the Rhine. Thus the French, without further fighting got possession of the whole of the difficult country cut up by the Lys, the Scheldt, the Dendre, the Seine, and the Dyle. The isolated fortresses of Landrecies, Ruesnoy, Valenciennes and Condé made little further resistance. Pichegru seized Malines and Antwerp, while Jourdan drove the Austrians through Louvain and Liegè.

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In October Pichegru was ordered to invade the United Provinces, and following the route sketched out by Dumouriez in 1793, he captured Bergen-op-Zoom, and finally wound up an arduous, but glorious, campaign by entering Amsterdam in January, 1795. Gertreydenberg, Dort, Rotterdam and the Hague had surrendered without a blow, and to crown all, Moreau with his cavalry and one battery of Horse Artillery crossed the frozen Helder to the Island of Texel, and captured the Dutch fleet. By February, 1795, the whole of the United Provinces had submitted to the French, and a large section of the people were demanding the French Alliance. Jourdan had 150,000 troops concentrated on the Meuse: in September his right wing under Scherer defeated Clerfayt, who had succeeded Coburg, and drove the Austrians across the Roer October 2nd, after which Jourdan's main army forced them back on the Rhine and captured Cologne, Andernach and Coblenz. Consequently in January, 1795, Jourdan was in contact, on his left at Cleves, with the Army of Holland, and on his right at Coblenz, with the combined armies of the Moselle and Rhine.

The result of the operations of the combined Army of the Rhine and Moselle in 1794, was that the Prussians were gradualy driven out of the Vosges, and finally fell back across the Rhine on October 6th: thereupon the Army of the Moselle, which was on the left, swung round through Trier and connected up with Jourdan at Coblenz on October 26th. On November 2nd the bridgehead at Rheinfels was seized, and on December 25th Mannheim was occupied, while Mainz and Luxemburg were invested. France had reestablished her position in Europe, thanks to the Army, and in spite of the Terror. She had defeated all her enemies on land, and added largely to her territories. France was ready for peace and some of the members of the Coalition even more ready. On April 5th the Treaty of Basel was signed, whereby Prussia gave France a free hand on the left bank of the Rhine. On May 16th Holland accepted the hard terms imposed on her, she became virtually dependent on France, and had to bear her share in the war against England. On July 22nd Spain secured peace at the cost of the Spanish half of San Domingo; and by the end of 1795, Saxony, the two Hesses, Portugal, Naples, the Duke of Parma, and the Pope, had all made their peace with France On November 3rd the Directory assumed the reins of government, and held them for four years until the *coup d'état* of Napoleon Bonaparte.

During this eventful year Jourdan would probably have succeeded in totally defeating the Austrians, if it had not been for the treachery of Pichegru, who purposely allowed himself to be defeated, and on December 31st, 1795, signed an armistice with the Austrians. Pichegru's reward for his treachery, in the event of his further employment of his army to overthrow the Directory and restore the Comte de Provence, was to have been the baton of Field Marshal, the government of Alsace, one million francs in cash and 200,000 *louis* in *rentes*, a hotel in Paris and the Chateau of Chambord.

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In Italy the campaign against the Austro-Sardinian forces was on the whole successful, and might have been completely so if Schérer had pressed on to Turin, instead of going into winter quarters.

The victorious army which had thus been evolved out of such unpromising beginnings, during a period of unparalleled anarchy in the civil government of the country, owed almost everything to the French soldier, who never forgot his enthusiasm for his beloved France, whether she was governed by an Emperor or by a so-called Republic. It was this burning enthusiasm working through a mass of trained veterans, which made the French armies practically invincible. By the end of 1795 a new type of general was evolving: the new generals were no longer politicians, they were before all things soldiers. They loved their men, they loved their profession, and they worshipped glory. The officers who had hitherto been promoted by the election of the soldiers or by selection of the Representative on Mission, were in future appointed principally from the military schools which the Directory set up. The strength of the army no longer consisted in the remnants of the old royal army ,nor in the fierce devotion of its soldiers to the principles of the Revolution. But its power lay in the fact that it was an army of enthusiastic soldiers, trained by years of continuous warfare, and organised entirely with a view to war. In future it gained its victories not because its opponents missed their opportunities and did not recognise their needs; nor because its enemies lacked cohesion and were demoralised by jealousies; but because it possessed the highest military talent of the age; and because its strategy, tactics and whole organisation were in unison with the aims and objects of the people and the rulers or ruler of France. ...

The parallel between France at that period and Russia now, which I venture to draw leaves one a lot to think about. It does not make one too optimistic with regard to the future in Russia, but at the same time it appears to me to show that the Army as an organisation is capable of rising superior to civil chaos, when the needs of the country demand it. The French Army undoubtedly came out of the melting pot into a state of cohesion and order long before the civil administration of the country: (Applause.)

THE CHAIRMAN: Would anyone like to make any remarks on the facts we have heard put forward by the Lecturer, or put any question?

MAJOR ROSTRON: I should like the Lecturer to tell us the ultimate end of Dumouriez. ...

BRIG.-GENL. STONE: Do you mean his subsequent career?

MAJOR ROSTRON: Yes.

BRIG.-GENL. STONE: I am awfully sorry, but I am afraid I cannot remember. I believe he served under Napoleon, but I cannot remember exactly what his subsequent career was.

THE CHAIRMAN: I will ask the audience to join me in a vote of thanks to the lecturer for the very able historical and military summary he has given us, of the most important revolution that has hap-

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pened within the world's history, I might also say, up to the present time. We hope to get this lecture into print, and I commend everybody to read it when it is in print and try and follow it out because it is very concentrated, and it is a very valuable contribution to the knowledge of that period, and also would be very useful in drawing the parallels which the Lecturer has suggested between the state of Russia now, and the state of France at the period he has dealt with. I will therefore ask you to join in a vote of thanks in the customary way. (Carried by acclamation.)

BRIG.-GENL. STONE: Ladies and Gentlemen: I must thank you very much for listening to me so patiently. All my facts are drawn from the "Cambridge Modern History," which I think is absolutely the most fascinating work on history, as well as the most accurate that anybody can possibly study. I began to study the "Cambridge Modern History" from the military side in connection with this subject, and I could not put the volume down until I had read the whole thing through. It is absolutely fascinating and splendidly written. Various authors contribute to it and its foundation is a purely scientific one. It is not written by one historian, who puts his own views into print, but it is written by a large number of most eminent historians working together on a scientific system, and I think that no criticism could possibly be levelled at any of the conclusions, or any of the facts which are arrived at in this volume.

I thank you very much for the cordial reception which you have given me.

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A PRACTICAL METHOD OF TRAINING GUNNER RECRUITS.

By Major J. I. D'Arcy, R.F.A.

OCULAR demonstration is the simplest and most practical form of instruction"—It is manifest that it is easier to learn how to manipulate a machine or set an instrument by being actually shown than by merely having it indifferently (which is the normal) explained without seeing how it is done. To do this and to save the time of a very limited number of guns the devices depicted in the accompanying illustrations were designed. They are so simple that they are almost fool proof and their uses are so obvious that they require very little explanation from me. They are many times the size of the real articles so that a whole squad can see them and read them at the same time. An intelligent Battery Wheeler was the only form of skilled labour used in their construction and no material was drawn for them; they are made throughout (with the exception of the dummy loaders which are an Ordnance issue) from biscuit and bacon boxes, odd bits of hoop iron, etc., etc.

Illustration No. 1, shows a dummy loader in use, here the recruit learns part of the duties of 2 and 4, i.e., to open and close the breech and to 'load' respectively.

Illustration No. 2, shows the recruit learning the remainder of No. 2's duties, i.e., the setting and reading of the Range indicator.

Illustration No. 3, shows the recruit learning the remainder of No. 4's duties, i.e., the planting of Aiming Posts and also getting his first introduction to the duties of No. 3, i.e., laying with the Rocking bar sight and giving the proper signals to No. 4 to direct him in planting the Aiming Posts.

Illustration No. 4, shows the recruit continuing to learn the duties of No. 3, i.e., reading and setting the sight clinometer.

Illustration No. 5, shows the recruit learning the duties of Nos. 5 and 6, i.e., learning to read and set the corrector bar and also to set fuzes.

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Illustration No. 6, shows the recruit learning how to read and set the No. 7 Dial Sight.

In actual practice before he is put to work with any of these devices the recruit has been taught how 'to fall in detachments rear' to 'tell off', to 'limber and unlimber' etc., etc., and it is only when he gets as far as the stage of "knowing all that has been depicted in the illustrations up to and including No. 5", that he is permitted to do his section gun drill proper; the saving in gun-time is obvious. The recruit has to be thoroughly acquainted with his section gun drill in its entirety before he is allowed to go to the instruction depicted in Illustration 6.

Illustration No. 7, shows a somewhat similar device for helping forward the training of Drivers without trespassing on the time of a very limited and rather overworked supply of horseflesh. The method employed is, in principle, the same as for the Gunners, e.g., Ocular demonstration"—the Instructor with his dummies on the rostrum *shows* the recruits *how* it is done, the horses in these teams are perfectly reliable and the driver can learn the use of his whip and reins without spoiling either their tempers or their mouths. The aids to driving and the signals can be learnt by this simple method without wasting a single moment of horse-time.

Illustration No. 8, shows the recruit learning how to fold and secure to the saddle both a full and an empty nosebag, and how to fasten his horse up on the line with either chain or headrope.

It is not suggested that by means of these devices alone, one can train a gunner completely without a gun or do even as much in proportion for a driver without a horse; but from actual experience it has been proved beyond doubt that such devices assist enormously in grounding beginners in elementary work, thus leaving the guns and horses free for the use of the more advanced men. The principle in a nutshell is "You do it like this".

[The illustrations are printed on the following pages.]

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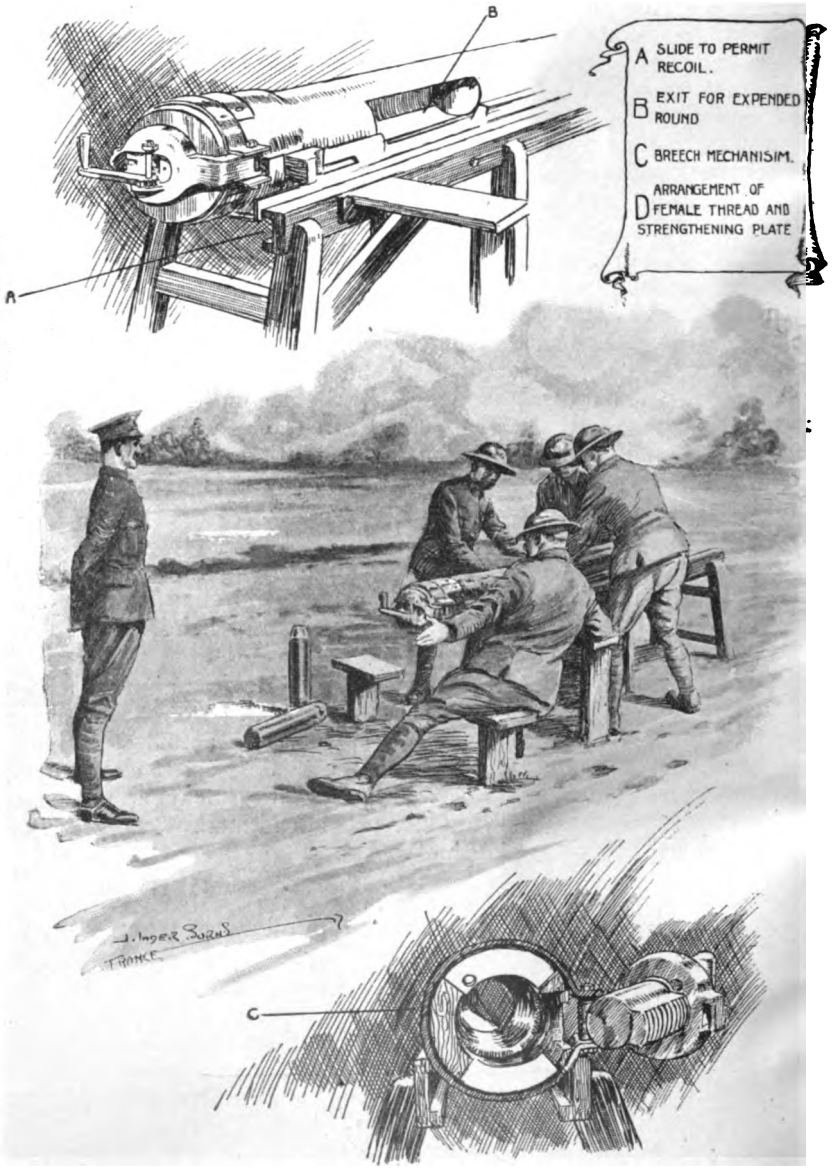

Illustration No. 1. Showing Dummy Loader in use.

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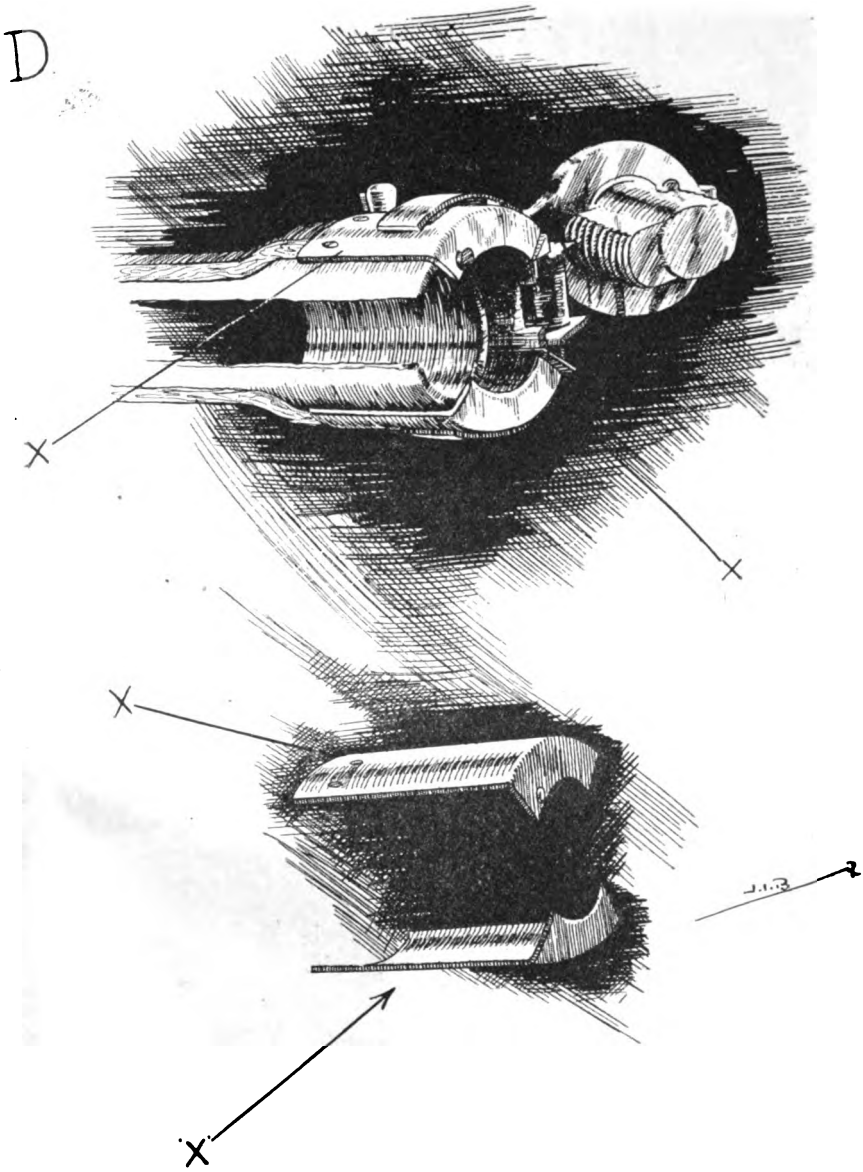

Illustration No. 1A. Enlarged plate of "D" Fig. 1.

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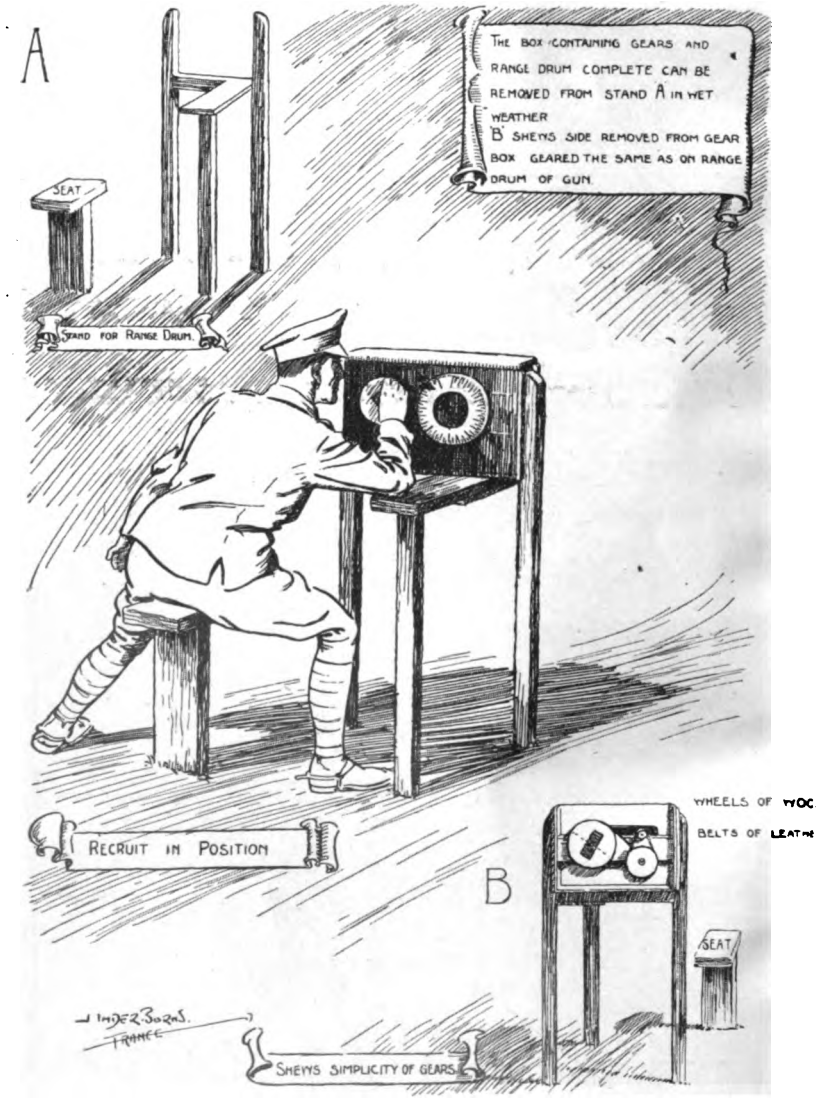

Illustration No. 2.

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Illustration No. 3.

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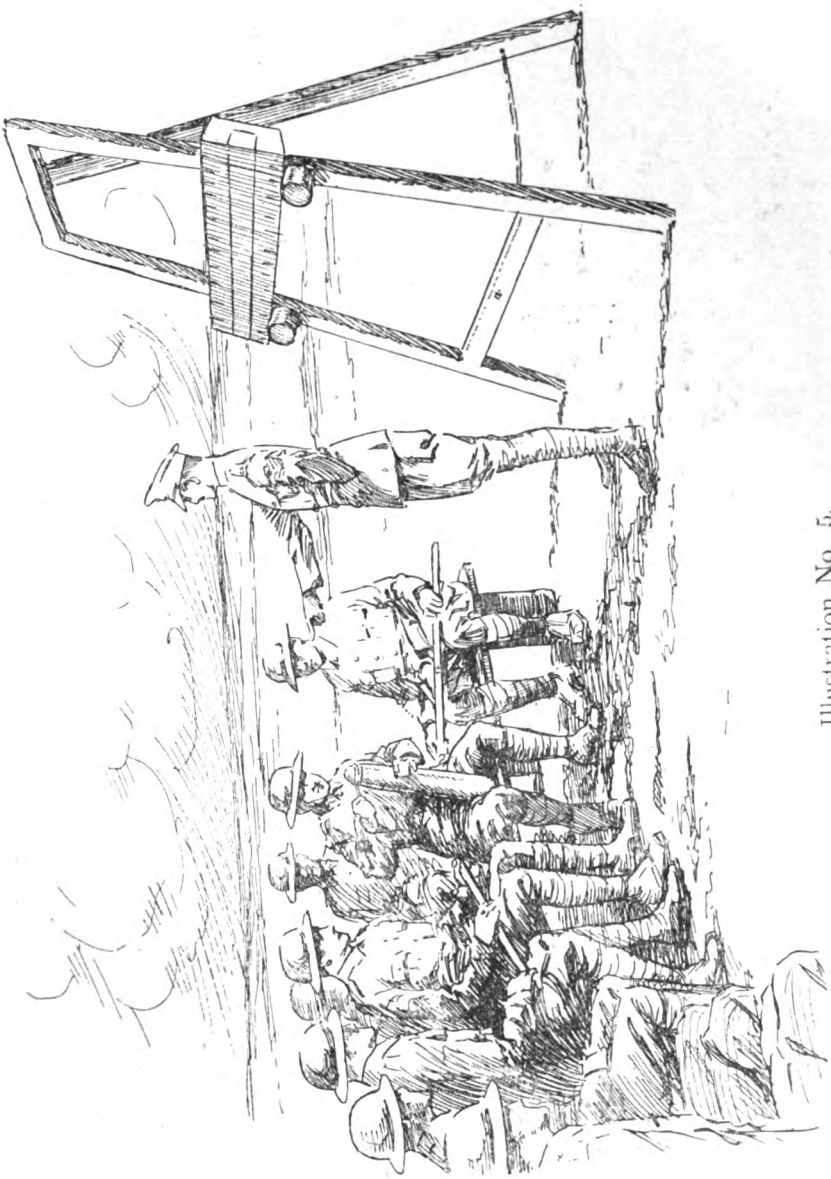

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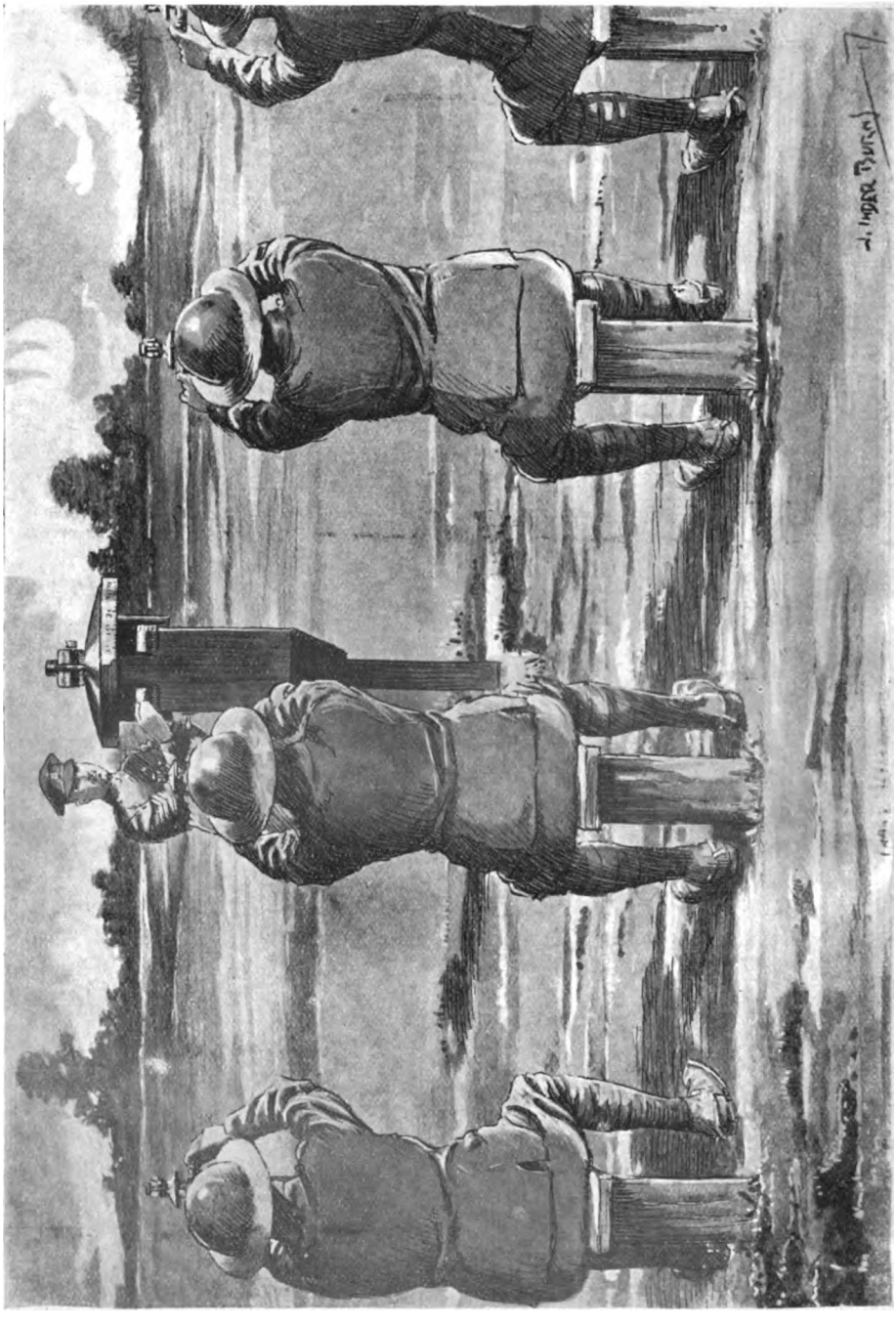

Illustration No. 6.

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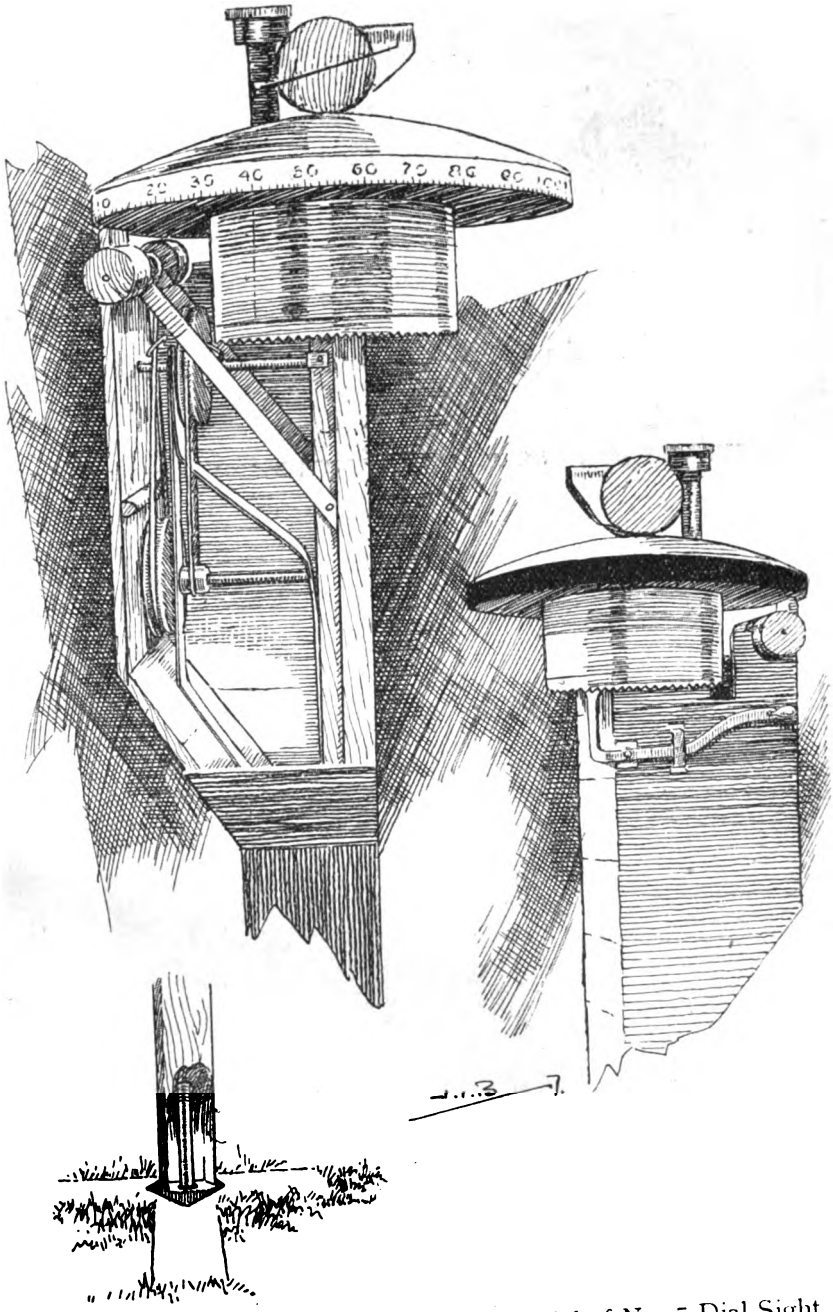

Illustration No. 6A. Enlarged view of Model of No. 7 Dial Sight.

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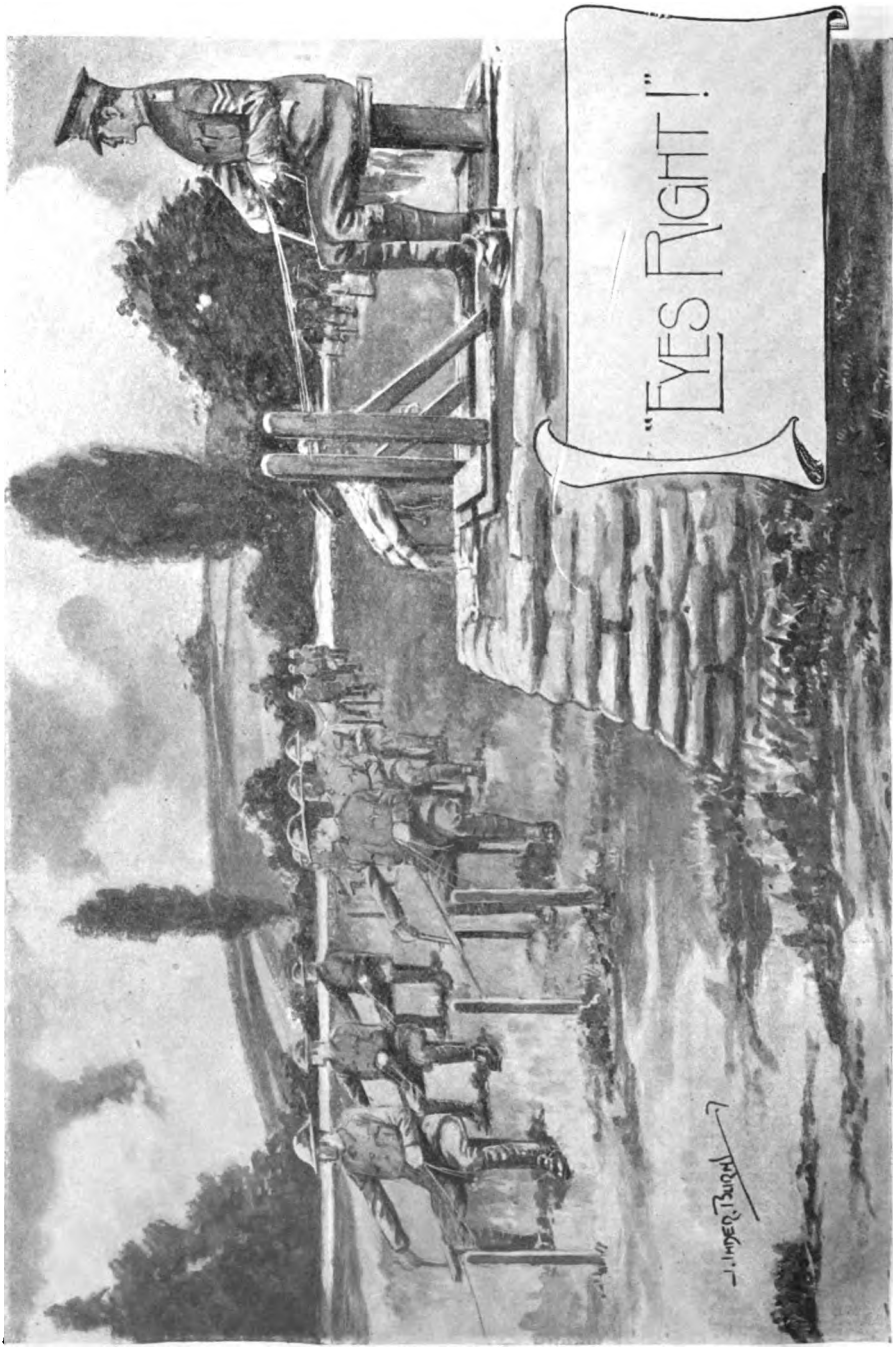

Illustration No. 7.

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Illustration No. 8.

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CO-OPERATION BETWEEN BALLOONS AND ARTILLERY.*

By Major D. Rainsford Hannay, Royal Flying Corps. British Army.

IT is a very well-known axiom in war that the closest co-operation between the various arms is necessary to secure the best results; and, when it comes to the question of captive balloons observing for artillery, the more that each unit knows about the methods of, and the difficulties experienced by, the other the better.

I propose, therefore, in this number of the "Field Artillery Journal" to describe the working of a balloon section of the British Army in the field.

As regards organisation, the balloon service of the Royal Flying Corps is divided into wings, companies, and sections. A section consists of four officers and 90 men and works one balloon. A company consists of two sections. A wing consists of all the companies in any one army.

The balloon now in use in the field is a streamline balloon, the invention of Captain Caquot, of the French Army. It has a cubic capacity of 950 cubic metres and is capable of lifting two observers to a height of 4000 feet. Each section is provided with a mobile winch, the engine of the winch being quite separate from the engine of the truck on which the winch is mounted. Theoretically, the balloon should be let up from the ground at a considerable distance behind the lines and then run forward on the winch with the balloon high up in the air; but, in practice, it is found that there are very few roads left near the lines which are fit for a heavy truck, and, even if one is found, it is probably too congested with traffic. Owing to these reasons, the majority of balloons in France, are stationary, at an average distance of about 6000 yards behind the line. Where sections have been able to move their winches forward, they have got within 4000 yards of the front line.

As regards observation of fire, the work of the balloon observer is chiefly with the heavier pieces of artillery, such as the

6-inch howitzers and the 4.7-inch guns.
8-inch howitzers and the 60-pounder guns,
9.2-inch howitzers and the 6-inch guns,
12-inch howitzers,
15-inch howitzers.

In the earlier days of the war, when there were fewer heavy

* From the U.S.A. "Field Artillery Journal," July—September, 1917.

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batteries, balloons used to observe for Field Artillery; but, owing to the great increase of the howiter batteries, and, also, to the somewhat altered rôle of the Field Artillery, very little work is done with them nowadays. In order to avoid confusion, Field Artillery in the British Army consists of only 18-pounder guns and 4.5-inch howitzers.

The balloon section is connected by telephone to all the batteries with which it is likely to work. The sketch gives a typical communication scheme of a section in the field. The upkeep of the telephone service is most important, and it is necessary that batteries should give as much mutual assistance as possible. Unless the lines are working well, the balloon might as well be on the ground, for all the good it can do. An advantage which a balloon has over an airplane, and one that compensates for a great many of the disadvantages, is the fact that the observer in the basket can talk direct by telephone to the battery commander on the ground and does not have to confine himself to a limited code as used on the wireless. To refer to the sketch, all the telephone lines shown, with the exception of those to Corps Heavy Artillery Headquarters, are the shooting lines of the section, and are used only when observing for, or when arranging shoots with batteries. Lines lead from the balloon camp exchange to an advanced exchange which is placed in a central position among the batteries. Now when the balloon is in the air, it is connected by a telephone cable to the winch, which is, in turn, connected by aerial line to the camp exchange, and, tapped in on this line, is the chart room of the section, where all the map work and the arranging of shoots with batteries are done.

I have purposely enlarged on the communications of a section for this reason: although the greater part of the lines are laid by the signal companies, when once laid, the balloon section is responsible for their upkeep and it will be seen, on referring to the sketch, that it is a pretty big job for the small telephone detachment allotted to a balloon section. Therefore it is of the greatest help when batteries assist, as much as is in their power, with the laying and maintenance of the line from their position to the advanced exchange (see Fig. 1, facing page 280).

The work chiefly alloted to the balloon consists of:

1. Destruction of villages;
2. Destruction of strong points behind the line;
3. Registering on cross roads;
4. Registering on exits from villages, woods and ravines;
5. Counter-battery work.

The method of observation employed is to observe on the line balloon-target, and, by the use of graticuled glasses, to send to the battery such observations as

1° 20′ Right,
30′ Left,
Line and over,
Line and short.

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Artillery officers will fully realize that it is not advisable to give obervations as regards range until the battery drops a shell fairly close to the balloon-target line. Then, when the observer is able to check the range, the battery commander will register by the bracket system, always remembering that to keep his shells falling on the line balloon-target it will be necessary for him to give deflection for each increase or decrease in the range ordered on the guns. This deflection varies according to the size of the apex angle in the triangle balloon-target battery.

The chief object of the observer is to describe to the battery commander briefly, but clearly, the position of each shot. This can frequently be done with reference to surrounding objects in the vicinity of the target which are shown on the map. For instance, even when a shot does fall wide of the target, it may be possible to check the range owing to its falling short or over some other object on the map, such as a road, stream, small wood, etc. Here the observer would give such an observation as, "40′ right and short of the small wood N.E. of the target." Such information as this is, of course, very valuable to the battery commander, as he can alter his range and deflection at the same time and thus save both time and ammunition.

I will try and describe a typical shoot on a fixed target, let us say the southern exit from a village including the houses on each side of the road. The night before the O.C. Balloon Section No. 24 (code word HAWK; code words are always used when telephoning near the lines in France) arranges to observe for No. 64 Siege Battery, 12-inch howitzers on railway mounting (code word BRASS) on the southern extremity of the village of Longueval, as soon as visibility permits (see Fig. 2). When the balloon goes up, and the observer is ready, and can clearly see the target, he sends the following information through the chart room to the battery.

1. Position of balloon. This is done by dropping a small plumb line about 20 feet long over the side of the basket and noting the exact spot over which the basket is hanging.
2. Height of balloon in feet.
3. Strength and direction of wind.
4. When he is ready to observe.

He should also arrange with the battery commander as to the exact reference point from which he will give his observation. In his case he will probably use the spot where the road joins the houses of the village.

The battery will then send to the balloon:

1. Time of flight of shell.
2. Nature of projectile. In this particular case there can be no question, as a 12-inch howitzer fires only high explosives.
3. When they are ready to fire.

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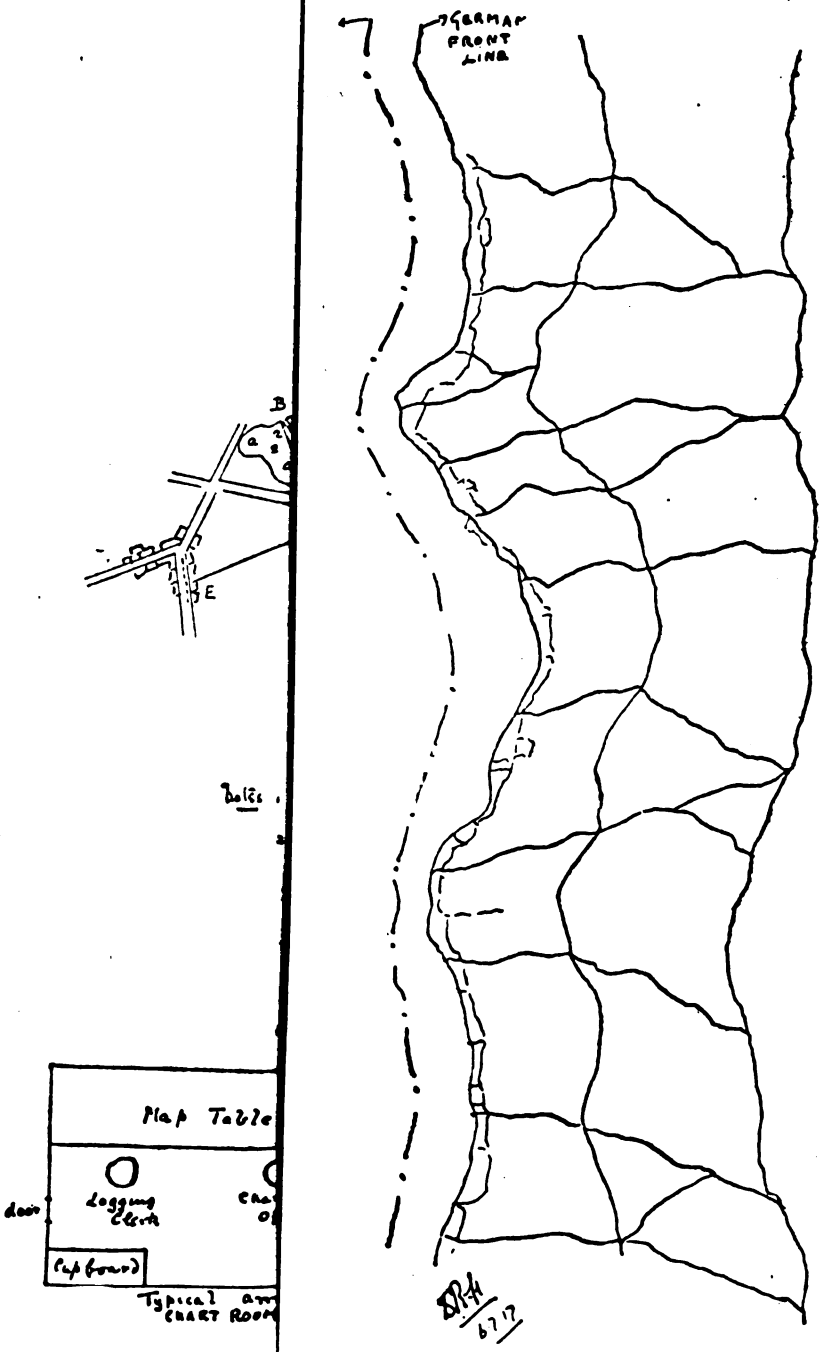
[To face page 280.



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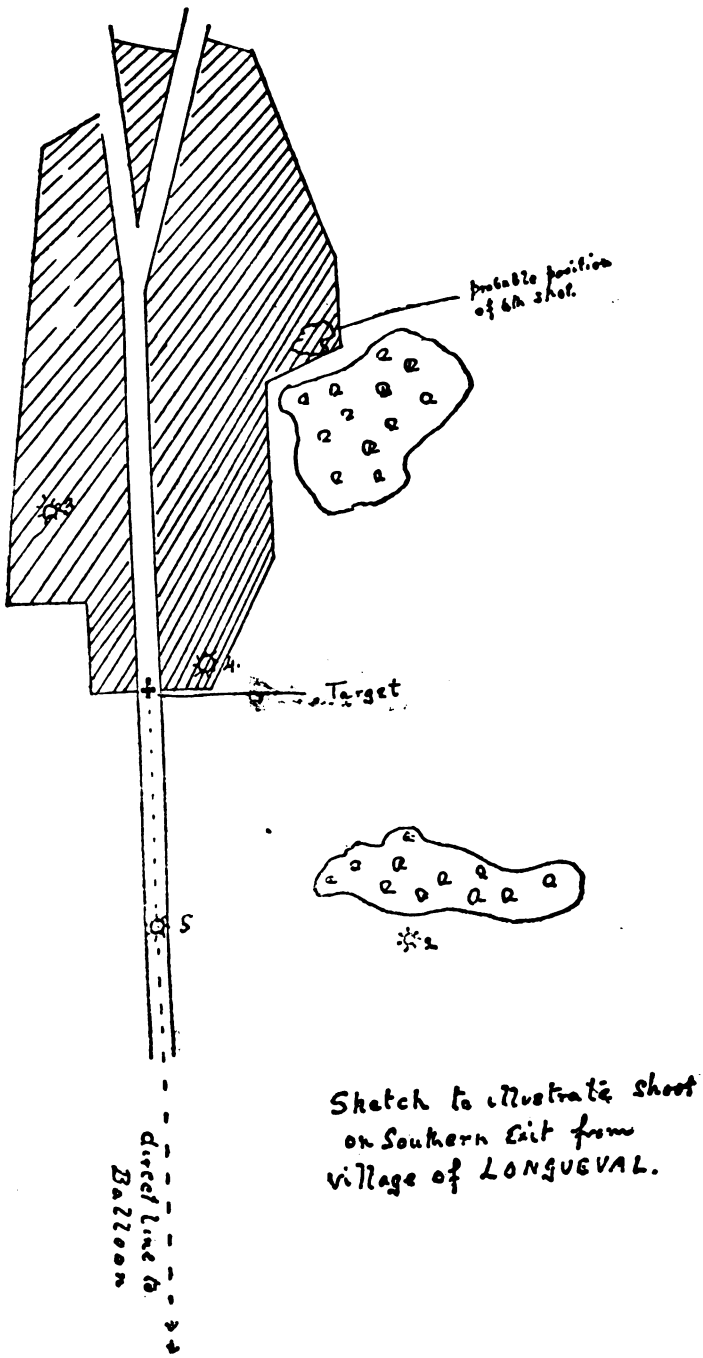

Fig 2.

19.

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When both observer and battery report they are ready, the battery will send, "Stand by," and the observer will then give, "Ready." As soon as "Ready" is received by the battery, the guns will be fired at once and "Gun fired" will be sent to the balloon.

When the battery sends "Gun fired" the chart room officer sets his stop-watch going and says, "Gun fired" to the observer, then at the correct time: "10 seconds to burst"; "5 seconds to burst; "4"; "3"; "2"; "1"; "Burst."

This relieves the observer in the balloon of watching with his glasses the whole time. He must keep his eyes fixed on the target, but need not strain them by peering through his glasses during the whole time of flight. When he hears "10 seconds" he gets ready, and at "5" puts them up.

As soon as he sees the burst the observer should make up his mind as quickly as possible what observation he will send down; first impressions are always best in balloon observations. This is sent down to the chart room officer, who passes it on to the battery. In practice it has been found best for all observations to be passed through the chart room. There is always an officer on duty there, and it his job to help the observer, and also to check his observations and query any which seem ambiguous or erroneous.

Let us say the first observation is:

"First Shot—30 minutes left."

"Short" or "over" is not given, as, the shot being wide of the target, the observer cannot say for certain.

"Second Shot—20 minutes right and short of the small wood S.E. of the target."

"Third Shot—5 minutes left and over; apparently hit a house, large cloud of red brick dust."

"Fourth Shot—5 minutes right; struck house just to right of target."

"Fifth Shot—Line and short of the road."

"Sixth Shot—Unobserved, but smoke and dust rising 10 minutes right or over from centre of village.

"Unobserved" should always be sent if the actual burst is not seen. Batteries must expect to get a number of unobserved shots, and must not get impatient with an observer who sends down several of them, as it is just as likely to be the fault of the battery as that of the observer. Also, the battery will know they are working with an honest and truthful observer and not with an over confident or nervous one; both of these types are capable of sending down anything, so long as it is something.

And so the shoot proceeds until the target is registered, when registration is taking place, or demolished if the battery is shooting for effect.

The above is a typical shoot on a normal and fixed target.

We will now discuss counter-battery work, which is perhaps the most important of the work allotted to balloon sections. To remove any possible doubt at the outset, a balloon cannot observe for a destructive shoot (that is to say, it cannot see the emplacements

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of a hostile battery); but what a balloon can and does do every day in France is to observe the flashes of hostile guns and note down as accurately as possible the map position, and, by ranging a battery on these flashes to stop him firing. The procedure is as follows:

The observer sees the flashes of a hostile battery. As quickly and as accurately as possible he notes their map position. (Map reading from balloons is quite the most important part of a balloon observer's training.) This reading is sent down to the chart room officer, who will check it with the records showing the position of all hostile batteries which had been previously reported. He will, if necessary, check the position of the flashes in conversation with the observer. When satisfied, the chart room officer will get in touch with the counter-battery group headquarters and inform them about the flashes. A battery will be detailed to engage the hostile battery. The chart room officer will get in touch with this battery through the advanced exchange, and, in a very short space of time, the hostile battery should be engaged and its activity stopped.

When reporting hostile flashes the observer will endeavour to locate the ground in our lines which is being shelled. This information should always be reported to the heavy artillery headquarters, as it helps in ascertaining the arcs of fire of the hostile batteries.

A balloon observer can observe for shrapnel by the following method:

When he sees the burst of the shell he first notes direction, say, 30 minutes right of the target, and then the height of the burst above the line of sight balloon-target in a vertical plane; this enables the battery commander to correct his fuze as well as his range and deflection. It is obvious that nothing should be said about range when reporting an air burst. An observation for time shrapnel would be sent like this: "30 minutes left and air over 20 minutes." The height above the line of sight can be gauged by the vertical graticules in the binoculars.

The balloon section should co-operate as much as possible with the airplane squadron attached to the corps for artillery observation, and, whenever possible, the officer commanding the corps squadron and balloon section should meet the G.O.C. Corps Artillery the previous evening to arrange the work of the succeeding day. When active operations are taking place it is often possible to have certain batteries placed at the direct call of the balloon, when the latter observes an active hostile battery, or a fleeting target, such as transport, on the road. This method tends to greater speed and to a closer touch between batteries and observers. Balloon observers frequently visit the batteries with which they work, and it is a strict order that, if anything goes wrong during a shoot, or if the shoot is unsuccessful in any way, the observer must, as soon as he comes down, visit the battery and find out what has happened at the battery end and work things out with the battery commander so that no mistakes will happen the next time.

Artillery officers must realize that mist, wind, and the position of the sun all militate against good balloon observing, and they

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should not press the observer to "have a try," or. "Well do your best," when he has once said that he cannot observe on the desired target.

Dead ground is also a handicap in balloon observation. Batteries should not ask balloons to observe on targets which, for instance, are situated just behind a large wood or at the bottom of a ravine. All balloon sections have maps prepared with all dead ground at the normal range and normal height shaded in, so batteries can always be previously informed if any particular target is invisible to the observer.

In conclusion, balloons have thoroughly proved their value in France and have relieved the airplanes of a great deal of artillery observation work. To get the best results artillery officers must appreciate both a balloon's powers and its limitations, and then by thorough co-operation much excellent work can be done.

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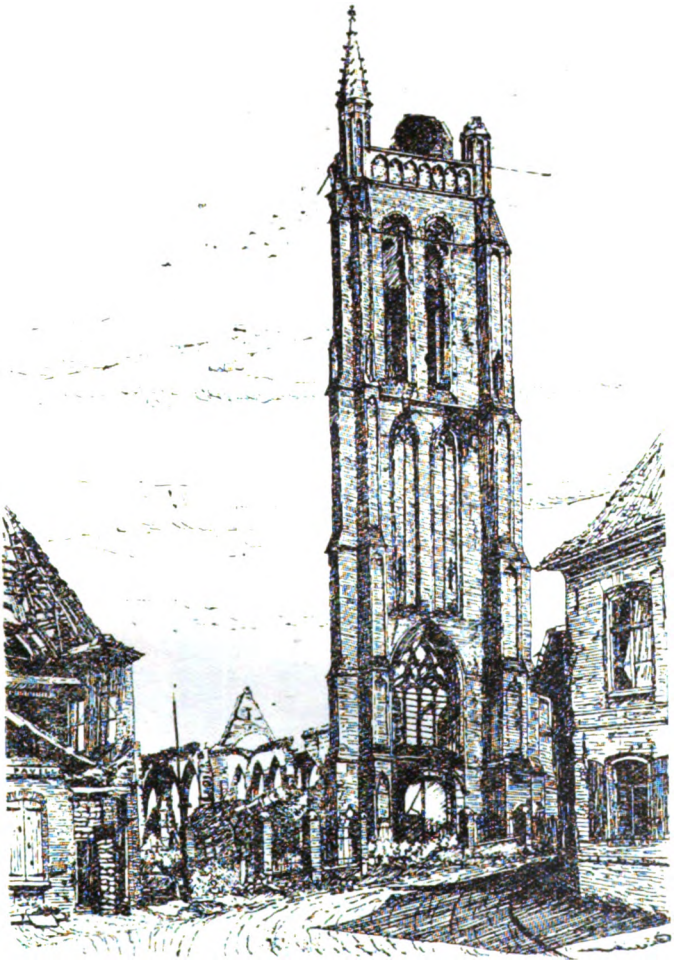
SKETCHES FROM THE FRONT.

By Major E. H. Lovell, R.G.A.

The accompanying interesting sketches by Major E. H. Lovell, R.G.A. were done before the push. One is of Ypres Cloth Hall & Cathedral, and the other of an old Church, in which a lot of our wounded were, and which the Germans shelled.



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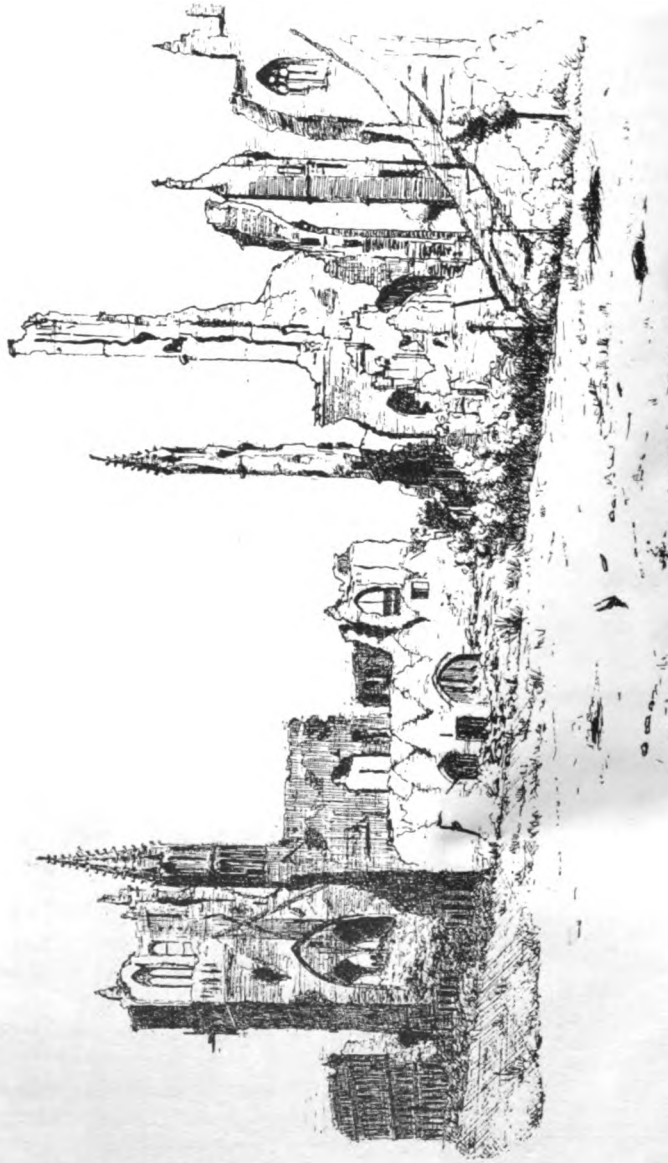

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THE GUNNERS' PART.

PLUCK AND ENDURANCE.

A GREAT RECORD.

Re-printed from *The Times*, of 3 November, 1917.

I do not know how it is possible to do justice to the work of our guns and gunners in these battles. In describing any attack one never fails to explain how largely success is due to the excellence of our barrage, nor could any attack hope for success without the preliminary work of the artillery, which nowadays is generally so overwhelming. But when the advance actually begins, the splendid behaviour of our infantry inevitably dominates all else. It is the gallantry and steadiness of the infantry that must in the last resort win battles. Without them there is no victory. But the few glorious hours of infantry advance are made possible only by the no less glorious, if less spectacular, weeks of labour by the guns.

That is the great burden which the gunner has to bear—a burden which is increased a hundredfold by weather such as we are having now. He gets no rest. In periods of what we know as "quiet" the guns thunder unceasingly night and day. I told in a recent despatch of the strain upon the guns, and how, by the quality of the weapons themselves, by the care and admirable work of the gunners, and by the unremitting labour of the mobile ordnance workshops, they endure much beyond the limit of what in all former wars was thought possible. But how is one to measure the strain upon the men?

Getting the Ammunition Up.

The reader at a distance perhaps can imagine guns at work only as he may have seen them on some battleship at practice, or from the solid peaceful embrasures in some coast fortress, or as pictured in old battle pictures standing ranged in orderly rows, on pleasant grass, amid a pastoral landscape, firing at visibly masked ranks of the enemy before them. Try, instead, to visualise these battlefields, with the endless expanse of grey-brown slime and stagnant water, across which our batteries are pushed forward with incredible difficulty, and where every round of ammunition to the forward field guns must sometimes be packed on human backs, for no mule or pony can get over the sodden, shell-torn ground. There is no shelter for guns or gunners either from weather or enemy fire. A brigade commander is lucky if he has a dug-out for his staff headquarters.

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Of rest in its true sense, of changing of clothes, or any comfort, there is none. What sleep is taken must be snatched on a waterproof sheet spread upon the slime. Meals are bolted as they may be amid the all-pervading horror of the mud. Men sit down on an ammunition-box to eat, and fall into a stupor as they sit. Officers drop asleep in the act of giving a command to the guns. And it never ends. Rain comes in torrents and icy winds sweep across the waste, and grey bitter days give place to more bitter nights, when the sky is aflame with star shells and rockets and shell bursts, and each day and night is the same with its turmoil and uproar and unending fatigue and mud. And always there are the enemy's shells; though it is the one kindly property of mud that it deadens the explosions of shells and makes their killing power less.

Many of our batteries, as they thrust forward, are necessarily compelled to take positions in the open with no sort of shelter to hide them from enemy observation, any more than there is shelter to protect either men or weapons from enemy fire. The enemy, not being compelled to advance his guns over these swept battlefields, has an immense advantage in these respects. He is in a fairly unspoilt country, and has leisure to make his gun positions, his pits, and dug-outs, with concrete quarters for his men. Several times I have mentioned the ruses which he employs to make his guns more difficult to hit, even not seldom at the expense of their efficiency. Our men, with no such ruses, no *camouflage*, or concrete, or shelter, must stick it out in the open and take what comes. And the light-hearted contempt with which they face all danger is a thing so much a matter of course that it is almost an insult to speak of it.

"Almost Superhuman."

The real marvel of what our gunners are doing, and have done, is not any measure of the courage which they exhibit in facing danger, superb though that may be, but it lies in the enormous physical and nervous strain to which they are subjected. I can give no figures, of course, nor can I be explicit as to facts, lest something said should help the enemy to inferences as to our gun power and the methods of handling our artillery of one kind or another. It must suffice to say that no guns are moved into the line and withdrawn in the same rotation as the infantry. All the guns have longer spells of work in the line than any infantry, and some incomparably longer than others. The gunners have often to face long spells of work which would, in any circumstances, test human endurance to the uttermost, but in conditions such as those which prevail here now, the things they have to do, the strain they stand, the spirit and cheerfulness with which they carry on, are almost superhuman.

The tale of what our gunners here have faced and done can never be told or understood; but if only a tithe of it could be made plain, England would be as proud of it as of anything in all her history.

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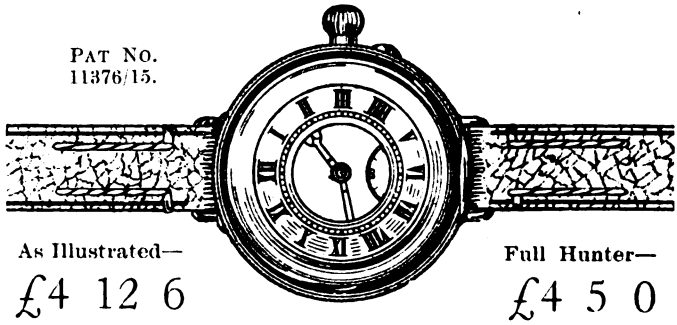

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Issued Monthly: Price 1/6 nett.

This Journal contains articles on engineering matters, both military, technical, and civil, and on general military topics.

Transcripts and Notices from the technical publications of Foreign Armies are also contributed.

The Journal is issued free to all Members and Associate Members of the Royal Engineers Institute. All Officers of the Royal Engineers (Regular) serving and retired, are eligible for membership. The following may be Associate Members: Officers of the Royal Artillery, of the Royal Reserve and Territorial Engineers; and of the Permanent Militia and Volunteer Engineers of all the Colonial Forces.

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ALPHABETICAL LIST OF OFFICERS OF THE R.A.

"The Alphabetical List of the Officers of the Royal Regiment of Artillery, and of those retired temporarily and permanently from the Regiment." Compiled, printed and published at the Royal Artillery Institution, Woolwich, S.E., 18. Single copy, 8d. Annual subscription (4 copies) 1/8, post free.

The above publication which has, owing to the great increase in the Regiment, increased from 74 to nearly 200 pages; contains the names of all officers, including those temporarily commissioned since the commencement of the war, with their ranks, honours, and much valuable information to the Artillery Officer.

It is of a convenient size for the office table, ($5\frac{1}{2} \times 7\frac{1}{4}$-in.) is well printed in clear type on a good quality paper, and should be in every office, especially nowadays, when so many changes are daily occurring.

[Facing first matter

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OUR ARTILLERY.

ADDRESSED TO YOUNG OFFICERS.

BY LIEUT.-COLONEL H. W. L. HIME, (LATE) R.A.

"HOW well the Artillery are doing" is a very common remark in these days, and we might accept the compliment without comment, were it not that those unfamiliar with military matters may suspect an implication that there were times when the Artillery did not do well. I make bold to say not only that is there no such implication, but that if there were it would be false. Since its birth in 1314 the Artillery has always done well, simply because it has been manned by British gunners.[1] There have been times no doubt when its effect in battle has been disappointing. In early days the weakness and scarcity of the guns confined their effect within narrow limits; later on the clumsy carriages hindered the movements of Artillery in the field; there have been systems of tactics which marred its usefulness; faults in the manufacture of guns and ammunition have at moments lessened its power;—but the courage and constancy of the gunners have been ever the same, yesterday as to-day, at the battle of Cressy as at the battle of Ypres. If the reader imagines that I am carried away by *esprit-de-corps*, he will surely accept the words of the Prussian General Scharnhorst who served under H.R.H. the Duke of York in our disastrous campaigns in the Low Countries: "the English Artillery has always been distinguished for its bravery. Their conduct at Minden gained for them the special thanks of Prince Ferdinand, and the successful defence of Gibraltar was entirely due to them."[2] These words were written before the Peninsular War. After facing us in the field for five years during this war a chivalrous Frenchman wrote:—"The British gunners are distinguished among other soldiers by the good spirit that animates them. In battle their activity is judicious, their observation is perfect and their courage imperturable".[3] It is a privilege for a young officer to join our Regiment and command gunners who at the present moment are displaying the same splendid qualities as they have always displayed in the past.

When and how did the Regiment arise?

[1] Under 'gunners' are included (for shortness) N.C. Officers, gunners and drivers.
[2] "Handbuch der Artillerie", 1806, II, 607.
[3] General Foy, "Hist de la Guerre dans la Péninsule," I, 291.

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I. OUR REGIMENT.

Very little is known about the *personnel* of our earliest Artillery; but already in 1485 "we find traces of a kind of regular troops, chiefly accustomed to the use of Artillery, maintained in the very few places where it was thought necessary or practicable to keep up the show of defence".[1] These were the Garrison Gunners, who were enrolled for life and were not available for general service. For service in the field special Trains had to be raised, which were disbanded at the end of the war. The system of garrison gunners naturally led to the abuses which called forth the wrath of Master Gunner Bourne: "a number of men take upon them to be gunners, yea and that Master Gunners, that are not sufficient nor capable . . . . but are altogether ignorant, standing upon no other thing but their antiquitie, that they have served as gunners so long time."[2] An old document exists showing that the ages of some of the Tower gunners in the time of Elisabeth ranged from 64 to 92 years.[3] Another century passed away before these men, heretofore civilians from the legal point of view, were brought under military discipline by a Warrant dated 22nd Aug., 1682.

In the wars of William III we meet with Albert Borgard and Jonas Watson, the future Colonels of the Regiment. After serving as an officer in the Danish Life Guards and Prussian Foot Guards, and as a volunteer in the Polish, Austrian and French armies, Borgard fell in with the Danish force of 7000 men serving under William III in the Low Countries and, joining the English army in 1692, was gazetted Firemaster in March, 1693,—the month and year in which Watson was promoted to the command of a Company in Flanders. Borgard fought in 17 battles and 24 sieges; Watson in 8 battles of the first rank and 18 sieges; and both were thoroughly worthy of the high positions they reached at last.

The confusion that reigned in the command of guns in the field at this period is illustrated by an incident that happened at the battle of Steenkirk, 1692, where an English and French battery fell foul of each other. The English battery was commanded (apparently) by Captain Mackraken of the Royals, who "had great success in laying the guns", and the French battery, "under a Commissariat officer, never threw away a shot."[4]

However suitable the system of raising special trains for each war may have been when the country enjoyed long periods of peace, it was found a grievous burden during the warlike reigns of William III and Queen Anne; the endless enlisting and disbanding of Trains became at last insupportable, and on the 26 May, 1716, George I formed for general service a small permanent Regiment of 2 Companies which in 1722 was named the Royal Regiment of Artillery. The officers, however, only obtained military rank some thirty years later, by a Warrant dated 30 Ap. 1751, and it was some

[1] Hallam's "Constitutional Hist. of England"; II, 131.

[2] "The Art of Shooting in Great Ordnance", 1587, preface.

[3] "Essay on the Regl. Hist. of the R.A."; Lieut.-Col. F. Miller, v.c., R.A., 1867, p. 6.

[4] Walton, "Hist. of the Brit. Standing Army", p. 729.

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time before the rest of the army recognised them as soldiers. As late as 1766 the Infantry at Gibraltar disputed the right of an Artillery officer to command the Garrison in the absence of the Governor, and the question was referred to the military authorities at home who decided in the Artilleryman's favour.[1]

As time rolled on it was found necessary that both officers and men should have a sound knowledge of their profession, and in 1741 an Academy was formed in Woolwich Warren for their instruction. In 1764 it was styled the Royal Military Academy, barracks having been built for cadets who were admitted without examination. But this happy-go-lucky system came to an end in 1772, when a cadet was returned to his father in order that he might be taught "reading and writing and the rule of three" before he came up for readmission. In 1774 there was an entrance examination including elementary arithmetic and "the declension of nouns and conjugation of verbs according to the Latin Grammar"![2]—already, it is clear, "the schoolmaster was abroad."

Meanwhile the Regiment waxed stronger and stronger. There were 19 Companies in 1756, and in 1793 there were 4 Battalions of 10 or 11 Companies each. Here we come to a parting of the way. Hitherto the Regiment had been a homogeneous whole. When Artillery was wanted in the field, Companies were supplied with field guns from the stores and with contract horses, which were withdrawn at the end of the war; but in 1793 a new unit, the Troop of Horse Artillery, was introduced by the Master General, the Duke of Richmond.[3] The following year, to get rid of the many evils of the contract system, an independant Corps of Drivers was formed. It was disbanded in 1823 when the Duke of Wellington introduced a Jekyll-and-Hyde system for the Companies, under which a man was enlisted as "gunner and driver."[4] This hybrid system was purged away by the Crimean war and the Indian Mutiny, and in 1859 the "Brigade System" was established, the Regiment consisting of the Horse Brigade, 6 Brigades of permanent Field Batteries, and 9 Brigades of Garrison Artillery. As early as 1877 this system showed signs of approaching dissolution, but it lingered on until 1889 when it spontaneously collapsed and was succeeded by the present simple and natural system. Finally, the Garrison was definitely separated from the Field Artillery in 1899.

In July, 1815, before the peace reduction began, the Regiment had 614 officers. In July 1917 there were 5978 active officers, together with 425 retired officers recalled to duty, and 3624 temporary officers. A large proportion of Artillery officers, seemingly, for our contemptible little army.

Whence came our guns?

---

[1] Col. Miller, as before, p. 4.

[2] Clode, "Military Forces of the Crown", II, 459. See also Col. J. J. Jocelyn's "Two Regimental Institutions", Proceed. R.A.I., XXXI, 139.

[3] The report of the Committee on Horse Artillery appointed by the Duke will be found in the "Mobility of Field Artillery", No. III, "Proceed. R.A.I. Vol. VII, p. 471, by the present writer.

[4] One is reminded of Maître Jacques in "L'Avare", *cuisinier et cocher*, and of the delightful passage in Act. III, Sc. 1 where Jacques says to Harpagon:—"Est-ce à votre cocher, Monsieur, ou bien à votre cuisinier que vous voulez parler? car je suis l'un et l'autre."

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II. OUR GUNS.

Our first guns were got from Ghent in the year of Bannockburn, 1314. They were called *busse* by the Flemings and threw darts, not round shot. The frontispiece of the "Origin of Artillery", showing one of these pieces in the act of being fired, is taken from an Oxford MS, dated 1327, and is the earliest known representation of a cannon. Accounts of our use of Artillery in war are wanting until we reach the battle of Cressy, 1346, where it produced a sensible effect. At the end of this battle, says Villani, "the whole plain was covered with men struck down by arrows and cannon balls (*pellottoli*)."[1] This use of the word *pellottoli* is conclusive that the *busse* period was already past, and that our guns at this time threw small balls similar to grape shot. They were too weak to stand the charge necessary for one large ball, the size of the bore.

We know very little about the Artillery during the remainder of the Hundred Years' War and during the Wars of the Roses, and it is not until the end of the 16th and the beginning of the 17th cent. that we get definite information about the nature and use of our ordnance, from such books as Master Gunner Bourne's "Art of Shooting in Great Ordnance," 1587; Master Gunner Eldred's "Gunner's Glasse," 1646; and Master Gunner Nye's "Art of Gunnery," 1647. From the facts they give us we can calculate that the muzzle velocity of a 9 Pr. Demiculverin was 1140 ft. per sec., and that of the 4·75 Pr. Saker 1050 ft. per sec. The muzzle velocity of a S.B. 6 Pr. of 1856 was 1483 ft. per sec. The mean range of 7 consecutive rounds from a Saker, charge 3lbs. elev. 5°, fired at Deal by M. G. Nye in 1640, was 703 yds.; that of 11 rounds fired at Shoeburyness in 1856 from a S.B. 6 Pr., charge 1½lbs., elev. 1¼°, was 688 yds.[2]

If the guns produced little effect in the battles of the Great Rebellion, it was mainly owing to the absence of trained Artillery officers.

Sir James Turner tells us that in 1671 the 16 Pr. culverin contained 270lbs. of metal to each pound of the shot, while formerly it contained only 100lbs. to each pound of the shot.[3] The explanation of this great increase of weight is the simple fact that our powder was considerably strengthened in 1647, and again in 1670[4]; the improvement in 1670[4] being partly due to the personal interest in ammunition taken by Charles II.

> Our careful monarch stands in person by,
> His new-cast cannon's firmness to explore;
> The strength of big-corned powder loves to try,
> And ball and cartridge sorts for every bore,
> Dryden's "Annus Mirabilis."

---

[1] "Istorie Fiorentini", in *Classici Ital.*, Milan, 1803; VII, 171-6. Villani died in 1348.

[2] The Probable Error in range of each shot for the Saker was 20 yds.; that for the 6 Pr., 52.6 yds. These figures illustrate the correctness of the ordinary expression for the probability of a small error in range, R cot. ϕ, where R is the range and ϕ the angle of descent.

[3] "Pallas Armata", 1683; p. 189.

[4] "Origin of Artillery", Table VII, p. 168.

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No change worthy of note took place in the guns during the reign of Queen Anne, nor in fact until the advent of the great Master General, the Duke of Richmond in 1782, who fortunately found himself assisted by a group of unusually able Artillery officers,—T. Desaguliers, Congreve (the elder), Blomefield, and later on W. Millar and Dundas. To them we owe the tangent scale; the equalisation of the wheels of the field gun and limber, by which the draught was lessened and all wheels became interchangeable; the pin-tail and trail-plate eye, which established a strong and simple connection between the gun and limber; Congreve's block-trail, which diminished the weight of the clumsy bracket-trail and enabled the carriage to reverse in a shorter space; and countless other improvements in the construction of guns and in equipment generally. So great was our progress, indeed, that a French Committee, which was appointed to inspect and report on the Artilleries of the Allied Powers assembled in Paris in 1818, unhesitatingly gave the palm to the English batteries.[1]

We fought the Crimean and Indian wars with guns of the Peninsular pattern, but in 1859 we adopted the Armstrong poly-grooved breechloader, with lead-covered projectiles. In the course of a few years various shortcomings in the ammunition came to light, and in 1866 we went back to a muzzle-loading system. This reaction lasted until 1886 when the breech-loaders revolted, and the defeated muzzle-loaders either abjured their errors or sank into conscientious objectors. Then began substantially the present system, the latest guns of which cause so much inconvenience to our cultured foe.

The year 1886 was marked not only by the defeat of the muzzle loaders, but also by the passing of gunpowder. The hour the French Government accepted the nitrocellulose explosive of M. Vieille, the knell of gunpowder was tolled, after an existence of nearly six centuries.

But who invented gunpowder?

III. OUR INVENTORS AND OTHERS.

In a small Latin work, *De Secretis Operibus Artis et Naturæ*, written by a Franciscan monk, Roger Bacon of Ilchester, in 1248, there is an anagram which baffled the learned for centuries. When solved at last in 1904 it turned out to be a recipe for gunpowder, and there is not the shadow of a doubt that Bacon was its inventor and concealed its composition in an anagram to escape the faggots and fire of the Inquisition. The next (known) recipe is a French one of 1338.

In 1543 Baude and Collet constructed at their works (in this country) cast iron mortars of 11″ to 19″ calibre, the calibre showing that the use of cast iron was then of long standing. But when and where was cast iron first manufactured? The Germans of course claim its invention, but when the question is thoroughly investigated (which it never has been), cast iron will doubtless be brought back to our foundaries in Sussex.

[1] For the Report see Napoleon III's "Le Passé et l'Avenir de l'Art." V. 72-84.

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It has been stated and restated that the French introduced the mortar éprouvette for testing gunpowder in 1686. Very likely they did; but the use of a small mortar for this purpose had been proposed by Master Gunner N. Nye of Worcester in 1647.[1]

In 1747 came the ballistic pendulum of Robins, which General Müller calls "an epoch-making machine."[2]

This brilliant English invention placed gunnery on a firm scientific basis.

In 1761 Robins prophecied that "whatever State shall introduce the general use (of rifled barrelled pieces) will acquire a superiority which will almost equal anything that has been done at any time by the particular excellence of any one kind of arms."[3] Sixteen years afterwards a 1 Pr. gun was constructed by Dr. Lind and Captain Alexander Blair, 69th Regt. which was not only rifled, but provided with telescopic sights pronounced by Col. Sir Hilaro Barlow to be in some respects "astonishingly modern."[4] This system fell through and nothing more is heard of the matter until 1792 when, by order of the Duke of Richmond, a trial was made at Goodwood between a 6 Pr. S.B. and a 6 Pr. rifled by the famous gunmaker Joseph Manton. The rifled gun failed to establish any decided advantage over the smooth bore, and the matter was dropped.[5]

But all this while a grand invention was being matured. In 1784, whilst a subaltern quartered in Newfoundland was reflecting upon the means of increasing the very short effective range of case, a brilliant and perfectly original idea occurred to him which ultimately led to the far-famed Shrapnel shell of 1803. The originality of Henry Shrapnel's idea escaped challenge until 1852, when Hauptmann Toll of the German Artillery wrote an article[6] to prove that a projectile on Shrapnel's principle had been constructed in 1573 by Master Gunner S. Zimmermann. It might be fairly supposed that Toll made himself acquainted with the nature of Shrapnel's shell before he wrote, but this is precisely what he did not do; and his article only proves that Zimmermann constructed a projectile for the same object as Shrapnel's, but on essentially different principles.

Oberst-Lieutenant Jähns in his "Handbuch einer Geschichte des Kriegswesens", p. 516, makes merry over the rockets invented about 1805 by Col. W. Congreve, Hanoverian Army, son of Gen. Sir W. Congreve, Bt. R.A.; and he classes them with the rockets of the Emperor Caligula, 37-41, A.D. But the gallant officer's *humor* remains pointless until he explains how his Romans contrived to make rockets without saltpetre, which was not discovered for 1200 years afterwards. Colonel Congreve bestowed on the service a much

[1] "Art of Gunnery", 1647; chap. XVI, p. 29.

[2] "Die Entwickelung der Feldartillerie", 1893; I, 23.

[3] "Mathematical Tracts", I, 341.

[4] "R.A. Journal"; XL, 172.

[5] The practice is analysed by Col. Sir H. Barlow, R.A. Journal; XL, 175. The first rifled gun fired by us in action (so far as is known) was in the defence of our miserable entrenchment at Cawnpore, 1857, where we used a rifled 3 Pr. which we found there—Indian I presume; Col. Jocelyn, "Hist. of R.A. and I.A. in the Mutiny", p. 147.

[6] "Archiv für Offiziere der K. Preuss. Artillerie", 1852; XXXII, 160.

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greater boon than his rockets by reorganising our gunpowder establishment. Although he retained the proportions 75 saltp., 15 char., 10 sulph. which had been reached in 1781, he so revolutionised the manufacture that modern gunpowder may be dated from 1815.

In 1807, a Scottish clergyman, Revd. Alexander Forsyth, piously following in the footsteps of Friar Bacon and the unknown German monk who invented cannon, proposed the use of fulminate of mercury in the priming of small arms. Colonel Peter Hawker followed up with the percussion cap in 1818; Mr. Marsh produced a percussion tube for naval guns in 1831; and Commander Moorsom R.N. invented a percussion fuze in 1850.

Captain E. M. Boxer, R.A. appeared about this time, a man whose talent for ammunition amounted to genius. In the final form of his wooden time-fuze, proposed in 1849, England possessed the best time-fuze in Europe. He devised a time-fuze for Armstrong B.L. guns in 1864, and when we reverted to muzzle-loaders in 1866 he adapted Shrapnel to rifled guns, a feat only inferior to the original invention of the shell. Space forbids my mentioning a number of his other admirable inventions, but I may not omit the words of the Secretary of State for War to a Parliamentary Committee in 1855: "to Boxer's untiring zeal, I am delighted to say, my means of keeping up the heavy fire at Sebastopol are entirely owing"; to which the Clerk of the Ordnance added: "Boxer has saved the Department from disgrace, and the country from imminent danger."
In ammunition Boxer had few peers and no superior.

Sir Charles Wheatstone, the practical founder of the Electric Telegraph, laid before the Master General in 1840 an electro-magnetic chronoscope registering to $\frac{1}{750}$ of a second, to replace the ponderous pendulum of Robins. It was not accepted and the matter was allowed to drift into the hands of a foreigner, Captain Navez of the Belgian Artillery, who handsomely admitted his debt to Wheatstone.[1]

In gunnery one of our greatest names is Andrew Noble. By his profound investigation of the products of exploded gunpowder, his experiments with cordite, his wonderful chronoscope, and his able direction of the Elswick Factory, he took a large share in bringing our ordnance to the excellence it has reached.

In 1868 the Range Finder invented by Captain J. P. Nolan was issued to Batteries. In range and accuracy the instrument was all that could be desired; but the first pattern involved running out two guns to work it and in a few years it was superseded by a simpler instrument by Capt. H. S. S. Watkin. This officer also invented a great number of other ingenious and useful instruments, amongst which, perhaps, the most widely known is his Position Finder.

Here I draw rein; first, because young officers will have ample opportunities of examining recent inventions themselves and, secondly, because it would be presumptuous on my part to speak of inventions most of which I have never seen.

[1] "L'Application de l'Electricité à la mesure de la Vitesse des Projectiles", Paris, 1853, pp. 4, 5.

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MISCELLANEOUS.

At the risk of wearying the reader, I add the names of a few members of the Regiment distinguished in subjects unconnected with Artillery.

Colonel W. M. Leake was a very eminent classical scholar and topographer, better known abroad perhaps than at home, on whose death Michælis pronounced him to be "the founder of the scientific geography of Greece."[1]

General Chesney, like Leake excelled in topography; but it was military, not classical topography. After surveying the basins of the Tigris and Euphrates, he made proposals for an overland route to India to which the Government turned a deaf ear. He also wrote a Report on Egypt, and M. de Lesseps declared in public more than once that he borrowed his idea for the Suez Canal from Chesneys suggestions on this subject.

General Sabine was elected Fellow of the Royal Society for his practical researches in terrestrial magnetism, and ultimately became its President. The present Vice-President of the Society is Major P. A. MacMahon, one of the foremost pure mathematicians of the present day, who is also President of the Royal Astronomical Society.

When Tennyson wrote his lines on the man—

> "Who breaks his birth's invidious bar,
> And grasps the skirts of happy chance,
> And breasts the blows of circumstance,
> And grapples with his evil star,"

one might almost imagine that he had Gunner William Sturgeon in his minds eye. Apprenticed to a shoemaker, this boy of extraordinary ability and energy drifted into the Regiment in 1805, and when quartered in Newfoundland was so struck by the effects of a great thunderstorm that he resolved to devote himself to the study of electricity. He read what books on the subject he could come by; and being unable to understand the formulæ, he taught himself the elements of mathematics, and studied French, German and Italian until he could translate the works of foreign electricians. Having served his time (15 years) and taken his discharge as a gunner—for he resolutely refused "the stripe"—he published in the "Philosophical Magazine", 1823-4, his researches in electro-magnetism; in 1825 the Society of Arts presented him with a silver medal and 30 guineas for his electro-magnet; in 1830 he described in the Philosophical Magazine his improvements in the voltaic cell, and in 1831 appeared his remarks on the induction coil. These achievements led to his appointment to the professorship of Natural Philosophy at Addiscombe; but in an evil hour he exchanged his professorship for the superintendance of the Victoria Gallery of Practical Science which collapsed shortly afterwards, and he ended his days in 1850 on a pension of £62/10 a year. The race is not always "to the swift, nor the battle to the strong, neither yet bread to the wise, nor yet riches to men of understanding."

[1] Sandys, "Hist. of Classical Scholarship", III, 242, 442; and "Dict. of National Biog."

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Some of the above facts are taken from the first history of the Regiment, "England's Artillerymen," published in 1865; a very interesting and trustworthy little book by Corporal James Alexander Browne, R.A. Band, afterwards Band Master, R.H.A. Band.

A few stray phrases, chiefly about our gunners, may perhaps remind a fastidious reader of Mr. Puff in "The Critic." If I had invested our gunners with qualities they do not possess, or exaggerated the qualities they do possess, there would be ground for his suspicion; but I have not swerved a hair's breadth from the bare truth. I wrote at the request of the Committee, R.A. Institution, in the hope of exciting the interest of young officers in the Regiment; and if this meagre sketch quickens their esprit-de-corps, the object of the Committee will be gained. And much more,—for efficiency is the outward and visible sign of esprit-de-corps.

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SHORT ACCOUNT OF CROSSING THE TIGRIS BY A DIVISION.

By Brig.-Genl. H. J. A. Mackey, C.M.G., M.V.O., D.S.O.

AFTER the signal defeat of the Turks in the Dahra Bend (right bank), all preparations for the crossing were ready for the night 23rd/24th February. Just before dusk that evening the three columns of infantry moved off to march to their respective crossing places, each column having with it thirteen pontoons carried on A.T carts. Specially selected rowers went with these pontoons, and all had been trained as far as was possible in the limited time available on the Hai. The same evening all batteries of the Division moved from their rest camp near Kali Haji Fahan to positions west of the Nahr Massaj which had been carefully reconnoitred previously, although no work had been done on them. These positions were quite close to the river bank, within 800 yards of the river bank trench on the Turkish side. They were beyond the original line held by the infantry of the Division who had to push on to cover the guns that night. The artillery of the Division co-operated and pushed batteries right up to the bank just east of Nahr Massaj and also in the loop of the Dahra Bend. The counter battery group (60-prs. and 4·5 Howitzers) also advanced their batteries.

Our artillery was therefore in a very strong position and able to bring a devastating cross fire to bear on the whole Shumran peninsula. The only difficulty about this was to avoid firing into each other.

The same evening the pontoons for the bridge, which had previously been taken up to a nullah some three miles from the river and so arranged as to took like a traversed trench when seen from an aeroplane, were advanced to a position of readiness by the proposed site of the bridge.

Artillery Plan.

As this account is intended to tell the Regiment what was done by the R.A., I offer no apology for putting this plan first.

There were very considerable difficulties in forming a plan, for three reasons.

(1) We knew practically nothing of the system of defences in the Shumran peninsula; this was unavoidable as everything had to be done to avoid attracting attention to this area.

(2) For same reason guns were entirely unregistered.

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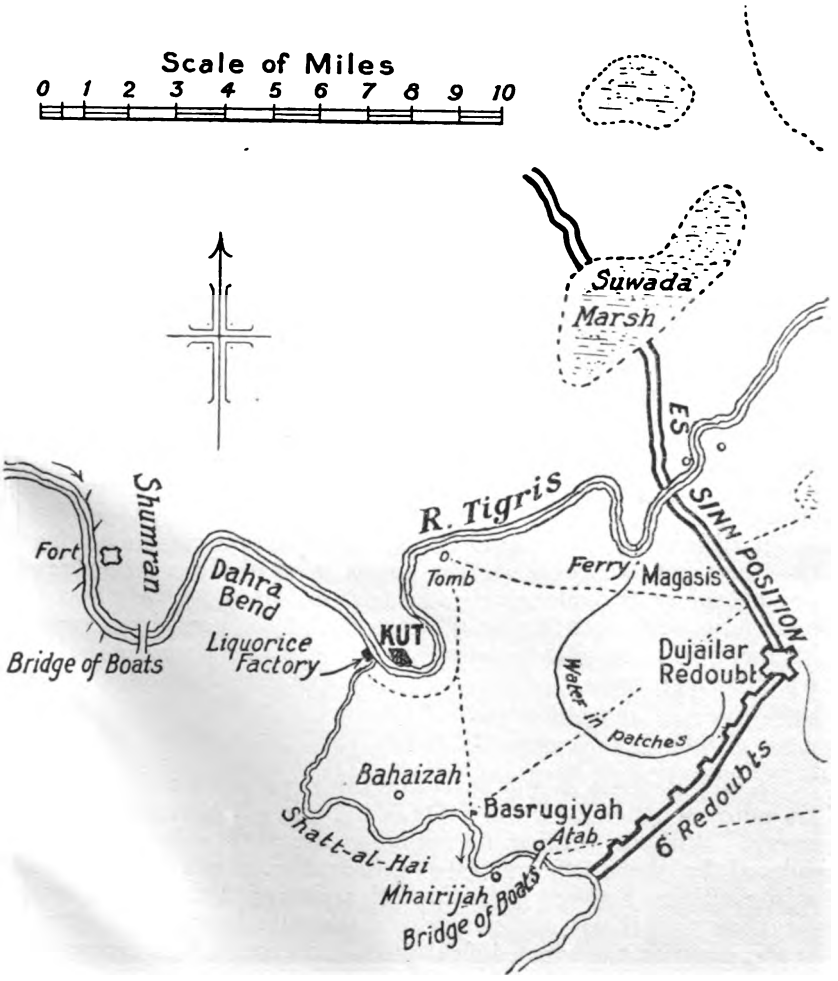
(3) The crossing was to start at 5.30, i.e. pontoons were to be launched then—and the earliest one could see to shoot was 6.10. The exact hour when guns could start depended on river mist, which is very tricky and uncertain.

There were two problems to consider:—

(i) Covering the actual crossing.

(ii) Covering consolidation after crossing and dealing with counter attacks.

As regards (i) it was fully recognised that until it was light enough to see, the guns could do nothing. Moreover, it was hoped to effect the crossing by surprise, and it was therefore inadvisable to attract attention by opening fire until necessary. At the same time a barrage along the river bank (see below) was arranged to deal with the eventuality of the crossing being delayed until after daylight and meeting with opposition.



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Finally the following barrages were arranged:—

No. 1. To deal with counter attack on our left flank after crossing. All 18-prs. and 4·5 howitzers of two Divisions on prearranged area on western portion of Shumran peninsula.

No. 2. To deal with counter attack on our left flank after crossing. Guns as in 1. Included whole area of Dahra Barracks, part of ridge north and nullahs to east.

No. 3. A belt of fire about midway down peninsula extending right across.

No. 4. A similar belt but further north.

No. 5. A similar belt but further south.

No. 6. A similar belt but still further south and leaving a big gap on east to be dealt with by batteries specially detailed in observation. This gap was necessary on account of danger of shooting into our own troops.

No. 7. Barrage along river bank.

No time table was laid down, but arrangements were made so that any given barrage could be opened at short notice; either for a period laid down in the order to fire or else for a burst of fire followed by batteries in observation.

Of the barrages arranged Nos. 6, 1 and 2 were fired in addition to a special barrage arranged to suit the progress of infantry.

Of these No. 6 was fired to assist progress, No. 1 completely broke up a counter attack, whilst No. 2 absolutely disorganised the enemy in their strongest quarter. Several observers, infantry as well as artillery have testified as to the utter demoralisation of Turks in consequence of this barrage.

Although barrages were made out it was also explained to all battery commanders that this was essentially an occasion for the exercise of initiative, and the success of the operation is largely due to the manner in which battery commanders on their ladders, assisted by F.O.O's across the river took on targets on their own responsibility.

In addition to this support there were ten 2″ trench howitzers along the right bank opposite the points selected for crossing, ready to wreck the river bank trenches on left bank if these were found to be strongly held, and further there were forty-five machine guns so distributed as to be able to bring a cross fire to bear on the southern part of the peninsula.

F.O.O's.

In Mesopotamia as a general rule this description is a misnomer. It is quite exceptional for the F.O.O's to be in a position to shoot the battery. Without wishing to minimise the very valuable services rendered by these officers, their principal role has been that of Liaison officers between infantry and artillery; although in recent operations they have earned great distinction in other directions. On this occasion the great difficulty to be overcome was communica-

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tion. The river, some 400 yards wide, was in heavy flood, and the only line which held out until the bridge was built was one taken across in a pontoon by an R.A. subaltern. This line consisted of a twisted D5 and D3 cable, and speaking communication lasted for nearly nine hours. The officer who laid this was severely wounded, but refused to be taken away until he had handed over the line to another officer. The work of our F.O.O's has always been good, but it is worthy of remark that by the time the two leading companies of the three crossing battalions were over, we had no less than five F.O.O's over, each fully equipped for visual signalling, and two lines across. One of these lines was broken almost at once, but practically all the information received came from R.A. F.O.O's.

Infantry Plan.

The actual crossing was made at three points: No. 1 Column upstream, just below the site of the bridge, No 2 Column about 400 yards down stream, and No. 3 Column another 400 yards down stream. At 5.30 a.m. all three columns started to launch pontoons and get the first parties into them. At 5.45 a.m. the first boats pushed off and got three-quarters of the way across without a shot fired at them. First boats were reported across by 5.55 a.m. No. 1 Column had the best position, boats of both Nos. 2 and 3 were carried a considerable distance down stream. The river was in flood and current very strong. Then followed a very anxious interval, as all the rowers of Nos. 2 and 3 Columns were either killed or wounded, and for some time we had to depend on one ferry. More pontoons were hurried up, and volunteer rowers from a Division were brought up in motors, and eventually all three ferries were re-established. Meanwhile at about 7 a.m. orders were issued for work on the bridge to begin; progress at first was slow, but as the work progressed they got out of the full force of the current, and by 5 p.m. the bridge was open for traffic. The construction of this bridge in under ten hours under heavy fire was a very fine performance. After the first parties had got across, ferrying continued as rapidly as possible, but the fog of war descended very thick. Communications with the infantry were practically impossible, and the reports received were most conflicting. All however agreed on one point, viz: that a considerable number of prisoners had been taken: at one time the number of prisoners must have almost equalled the number of the attacking force actually across the river. It was some time before the Turkish artillery opened fire, but subsequently they fired a lot. Owing to conflicting reports it was very difficult to find out exactly what was holding up our infantry, but soon after midday a definite report was received from No. 1 column, guns were turned on, and after that the infantry very speedily reached their first objective. In the evening the 15-in. howitzers were very active indeed, a sure sign that they intended to withdraw.

After the bridge was completed the work of getting the remainder of the infantry of the division across was put in hand and the position gained was made good. No artillery crossed that day as the position had not sufficient depth.

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At 6 a.m. on the 25th the fight started again; the artillery made a rolling barrage in front of the infantry, and by 8 a.m. practically the whole of the peninsula and four guns were in our hands.

The artillery of the Division had pushed on N.W. on right bank, right up into the next loop so as to enfilade any counter attack developing against our left flank. By the night of 25th all the Division Artillery was on the left bank, our troops were firmly established on the left bank and the Turks were retiring rapidly.

From the telegrams hitherto received, the difficulties of the crossing do no not seem to have been fully realised. The river has always a very strong current; at this time it was in full flood. The rowers had had very little chance of practice and were called upon to cross a river 400 yards wide in the dark with very slight knowledge of what was in front of them, beyond the fact that there was a trench along the river bank, held in unknown strength. Casualties amongst rowers were heavy, the staff on the beach also suffered heavily and all later crossings were made under heavy shell fire.

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METHOD OF CORRECTING ERROR
Introduced by use of near Auxiliary Aiming Post.

By Major E. R. Dain, R.G.A. (T).

WITH reference to the method of laying with a near auxiliary aiming point referred to on page 45 of No. 2 Vol. XLIV of the Journal of the R.A., I desire to point out that it has been in use in several batteries out here since about Sept. 1916 when I first introduced it in my old battery to meet special circumstances; and have since advocated its use to many officers out here and also when on a B.C's course at Shoeburyness. My reason for writing is that experience has shown that purely from the point of view of drill and avoiding mistakes, a slight departure from the method of applying the system as given by Lieut. Kennedy is desirable. I notice he suggests making the corrections on the occillating sight but I think this is liable to cause confusion with other corrections such as concentration, etc.

The rules all layers apply are simply these:—

(i) Lay on the far post with angle given.

(ii) Switch on the *Dial* to the near post.

(iii) Relay with the traverse on the far post.

(iv) Take out Dial Sight and reset it to the angle given.

With 60-pdrs. and I should think many other heavy pieces it is desirable to remove the dial sight for firing and with experts this involves no delay. This gives the layer an opportunity of carrying out rule (iv) which although not necessary in theory appears *most desirable* to prevent any possibility of the original angle being lost sight of for the purposes of switches, etc.

In cnclusion I would remark that the main use of the system is to avoid the error due to the movement of the sight relative to a near aiming point when the gun is trailed.

The jump is usually a minor consideration especially when the aiming posts are behind as they usually are. Some time ago I gave an account of the method to my brother in Salonika who had been bothered about the corrections for an 18-pdr. which had rather a large zone and always had to use aiming posts. I believe he found it satisfactory.

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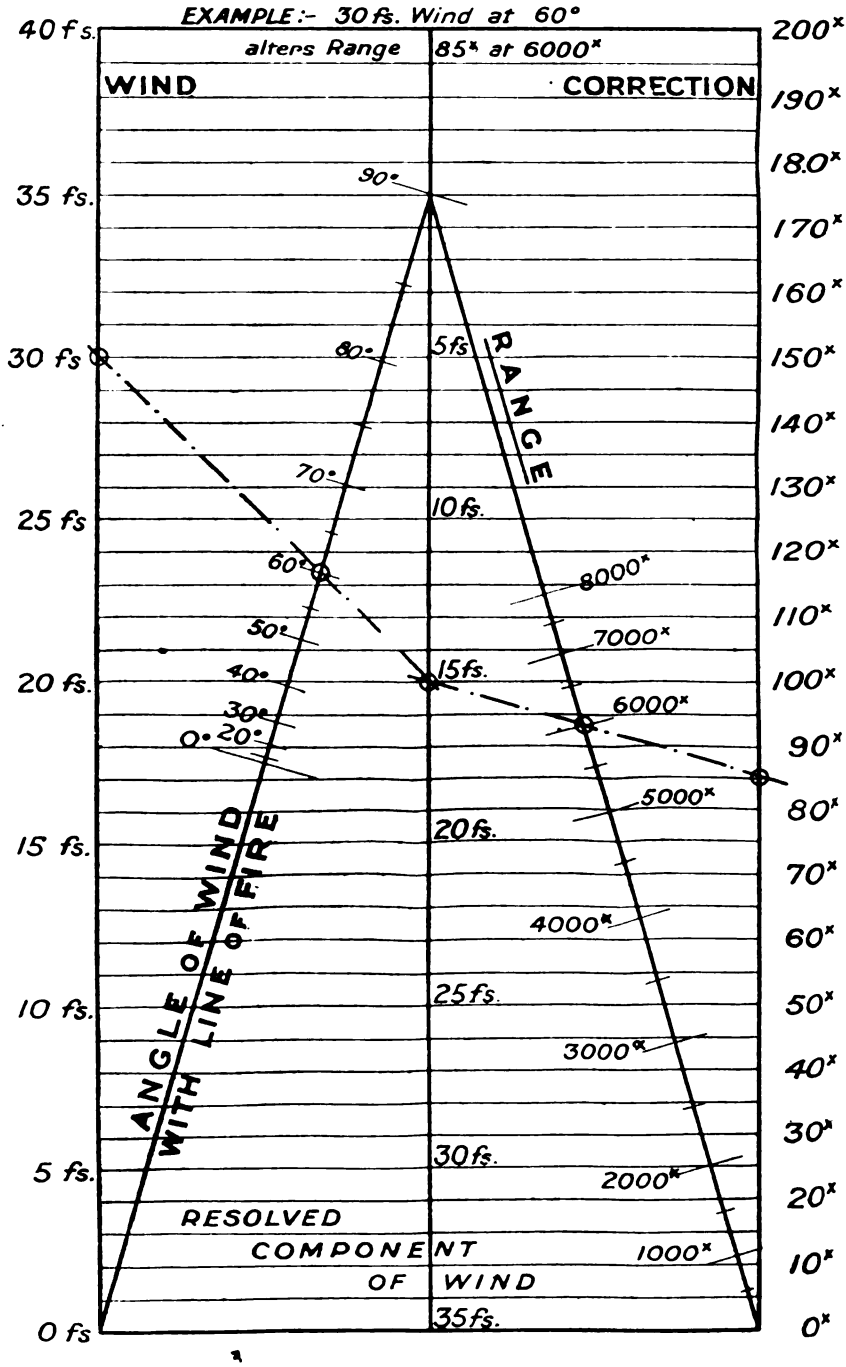
WIND NOMOGRAM

(18-pr. Q.F. Gun).



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THE "CONE OF FIRE" of High Velocity Guns; and its relation to Clearance of Crest problems.

By Lieut. F. C. Higgins, C.F.A.

THERE apparently exists among Officers of the Field Artillery a very common misconception of the structural shape or form into which a series of trajectories, fired at the same elevation of the gun, will group themselves to form the so-called "cone of fire". This erroneous impression is likely to lead to a failure to appreciate correctly some of the aspects in clearance of crest problems. Moreover, in a recent article which appeared in the July number of "The Journal," entitled "On Clearance," the writer, Lt.-Col. H. W. Hill, D.S.O., suggested a handy rule for determining safe angles of clearance for the 18 pdr. gun, which unfortunately was not accompanied by sufficient examples, or at least with a sufficient explanation, to clearly indicate the obvious limitations to this rule in certain cases. A further misconception would, therefore, be likely to result from this article. Accordingly the writer has been prompted to offer the following remarks in an endeavour, firstly, to correct the wrong impression which seems to exist concerning the cone of fire of high velocity guns, and, secondly, to follow up these remarks with a discussion of the correct method of solving clearance of crest problems, in the course of which discussion, the particular limitations to Lt.-Col Hill's rule will be pointed out and a modification of it suggested which will apply in all cases.

First, then, as to the common misconception of the geometrical shape which a cone of fire assumes. The point in question has nothing to do with the characteristic curve, or "droop," common to every cone of fire, due to the force of gravity, but rather it is concerned with the vertical width of the cone at different ranges, and more particularly the vertical angle at the gun position which these different widths subtend—in other words, it is a question of the *angular measure* of the cone. The misconception undoubtedly arises simply from a failure to give the matter sufficient thought rather than from any lack of knowledge on a point in gunnery.

Fig. 1 illustrates this false impression.

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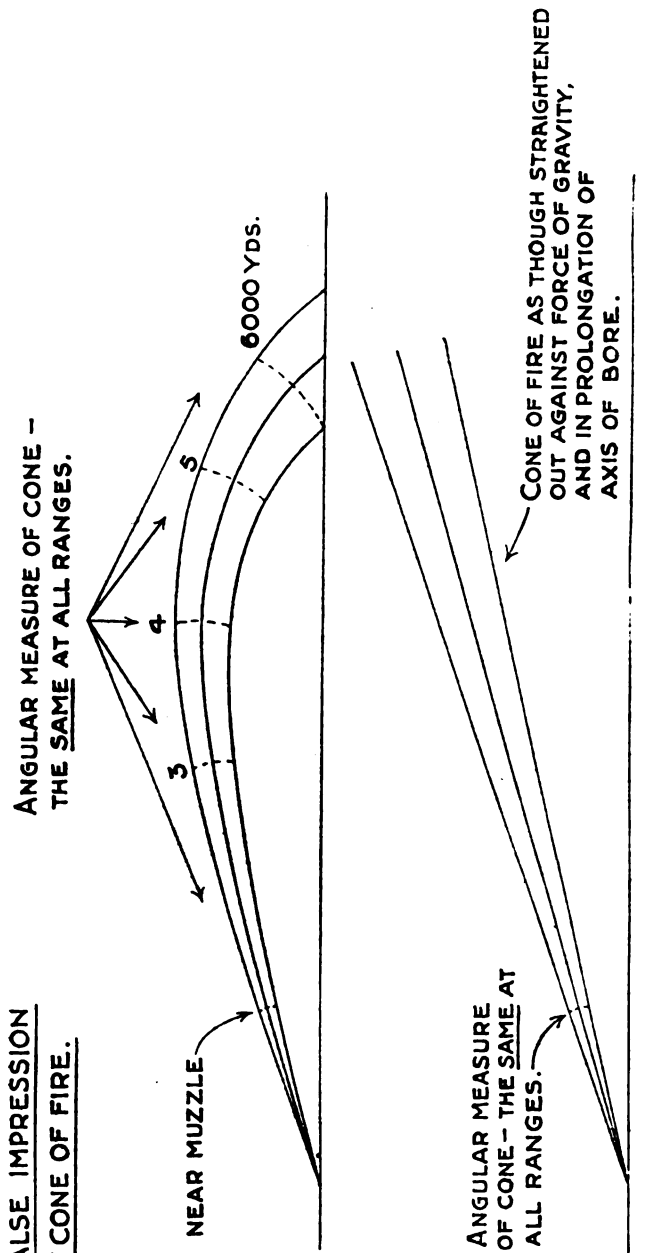

FIG. 1. – FALSE IMPRESSION OF CONE OF FIRE.

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In the upper diagram is shown a cone of fire whose angular measure (in a vertical plane) as measured from the gun position, is the *same* throughout the whole length of the cone whether the measurement be taken near the muzzle, or at any of the various ranges up to the extreme limit of 6,000 yds, as illustrated. This is the common misconception (which it is desired to correct) and it is

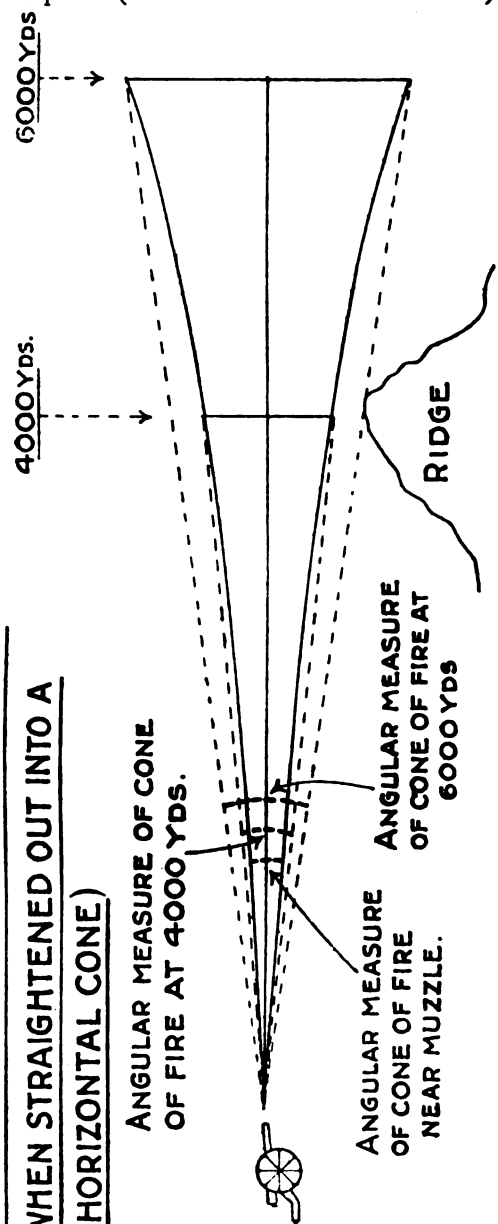

FIG. 2 — A MORE CORRECT REPRESENTATION OF A CONE OF FIRE (WHEN STRAIGHTENED OUT INTO A HORIZONTAL CONE)

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illustrated a little more clearly in the lower drawing which has been made to represent the same cone as though it were simply straightened out against the force of gravity and in direct prolongation of the axis of the bore. Here it is plainly to be seen that the cone has but *one* angular measure throughout its whole length.

On the other hand, in Fig. 2, is shown a more correct representation of a cone of fire when cut by a vertical plane; though here again, for the purpose of clearer illustration, the cone has been straightened out against the force of gravity into a horizontal cone. The relative position and curvature of the trajectories within the cone itself, however, have remained unchanged, and hence the illustration is quite applicable for the purpose of making clear the point in question.

A glance at Fig. 3, on another page, by the way, will give an idea of what the same cone would look like if drawn to illustrate in addition its characteristic "droop" under the influence of gravity, though in either case both the height of the curve and the width of the cone in proportion to the range have been greatly exaggerated to make the illustration clearer.

From Fig. 2, it will be seen that although the cone of fire issues from the gun position with practically the same angular measure as in Fig. 1, it reaches, however, a much greater width in vertical cross-section at 6,000 yds., than does the cone in the preceding figure at the same range. In other words, the initial "angle of opening" at which the outermost trajectories (which form the limits of the cone) issue from the gun position does not remain constant, but on the other hand these trajectories tend to steadily increase this initial angle of opening as the range increases. A glance at the above figure will illustrate this tendency quite readily. It represents the *correct* conception of a cone of fire in contrast to that illustrated in Fig. 1. The effect upon the angular measure of the cone, at different ranges, of this tendency of the outer trajectories to constantly widen out in the form of an outward curve will be apparent when cross-sections at right angles to the central axis of the cone are taken at 4,000 yds. and 6,000 yds., and a comparison made of the angle subtended by each at the gun position. It will be found that in this case the angular measure of the cone becomes greater as the range increases, and this is clearly indicated in the figure by the three dotted arcs near the apex of the cone. Hence it may be assumed that in any normal cone of fire the angular measure of the cone will be relatively small near the gun position, but will tend steadily to *increase* with the range.

As a matter of fact, a cone of fire in its initial stages, near the gun position, represents little more than the mere inaccuracies of laying combined with the irregularity of the "jump" imparted by the gun itself. These initial inaccuracies, however, are gradually increased by the resultant and constant action of all the forces acting upon the shell during its flight, with the result that the vertical width of the cone will assume much greater proportions, range for range, than would otherwise be expected if the cone were to keep to its initial angle of opening and thereby retain the same angular measure at all

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ranges. The extent to which this initial angle of opening, representing the irregularity of "jump" and inaccuracies of laying, is increased in the later stages of the cone, is largely a direct measure of the combined effect of variations in the charge, and of small differences in the weight or shape of the shell which affect the latter's ballistic properties. A typical illustration of the effect of this upon the cone may be gathered from a comparison of Fig. 2 with the lower drawing in Fig. 1.

A clear distinction should be made here between what the writer has termed the "angle of opening" of the cone, and, on the other hand, the *angular measure* of the cone. In a normal cone both of these increase alike as the range increases, but they are nevertheless quite different. The former is the angle formed by any two tangents to the outermost and opposite trajectories when these two tangents are taken at points vertically opposite each other and are produced towards the gun position till they meet. The latter, on the other hand, is simply the vertical angle (measured always from the gun position) which is subtended at different ranges by a cross-section of the cone taken at right angles to its central axis. It is this latter—the angular measure of the cone—with which alone the following remarks are concerned, the "angle of opening" having been mentioned merely to facilitate the foregoing explanations.

Let us now consider how the angular measure of the cone of fire in the case of the 18 pdr. gun is actually to be measured, for it is well that this be understood before considering the matter of clearing a crest. Fig. 3 will illustrate.

Here is a characteristic cone of fire cut by the horizontal plane G D E F at a range of 6,000 yds. It is desired to find the angular measure of the cone at this range. The limits of the cone are represented by the two trajectories G.D. and G.F. so that the point D represents the shortest round of the 100% zone and the point F the farthest round. The trajectory G.E. is the centre of the cone and for all practical purposes it represents also the centre of the 100% zone at the point E. Now the 100% zone at 6,000 yds. is given in the Range Table as 200 yds. It is also known from the same source that at this range 5 mins. of elevation will alter the point of impact of the shell by 23yds. Hence, $\frac{200}{23} = 8\frac{16}{23}$ = the number of "5 minute" elevations which would have to be given to the gun to raise the shortest trajectory G D from its point of impact at D to the point of impact F. This is equal to a total of $(8\frac{16}{23} \times 5) = 44$ mins. of elevation. Hence, 44 mins. is the angle at the gun position (measured in terms of an elevation of the gun) which is subtended by a cross-section of the cone at right angles to its central axis and at 6,000 yds. range. Such a cross-section is shown in the figure as the line A, and it will be seen that this is not necessarily a "vertical" line with respect to the horizontal plane, but only in respect to the central axis of the cone corresponding to the "mean" trajectory. Of course the actual cone of fire of high velocity guns is so flat (in contrast to the diagram) that

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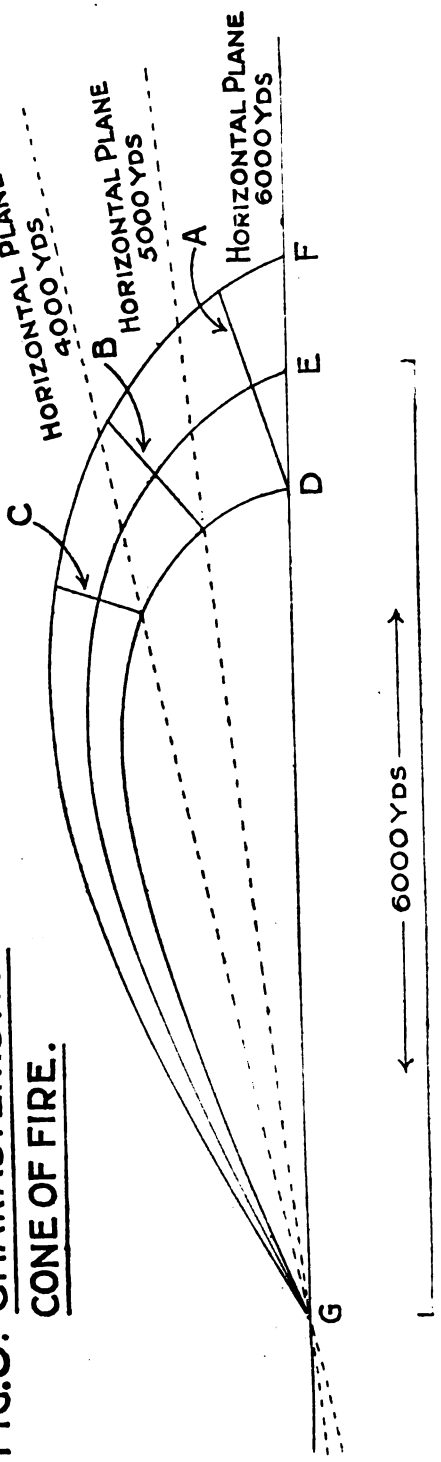

FIG. 3.—CHARACTERISTIC CONE OF FIRE.

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a cross-section taken perpendicular to the axis of the cone is, for all practical purposes, perpendicular to the horizontal plane as well. In any case, since the angle at the gun position, which the cross-section subtends, is one which is expressed in terms of an elevation of the gun, it is, therefore, the correct angular measure of the cone in so far as it affects the problem concerned. Hence, 44 mins. can be taken as the angular measure of the cone at 6,000 yds. Similarly, the angular measure at any other range may be determined—for instance, at 4,000 yds. and 5,000 yds., as indicated in the figure, in which the respective horizontal planes are represented by the two dotted straight lines which cut the cone at these ranges, and the corresponding cross-sections are also indicated at C and B. The actual values for the angular measure so obtained (which are tabulated in a later paragraph) will be found to be comparatively small at short ranges but increasing considerably as the range increases—and hence this is a definite proof of the correctness of the view concerning a cone of fire which I have endeavoured to point out.

I will now turn to the second object of these remarks, which is to explain the correct application of the foregoing principles to clearance of crest problems (in the case of the 18 pdr. gun) and in the course of this discussion reference will be made to the limitations of Lt.-Col. Hill's rule.

The particular aspect of the problem in clearing a crest, which it is desired to explain, is the question of what *additional* angle must be added to the quadrant elevation which will just clear the crest in order to ensure the safe clearance of the whole cone of fire, that is to say, that part of it which falls below the centre or mean trajectory. Naturally this will depend entirely upon the angular measure of the cone at the different ranges, and as a matter of fact, the actual angle to be added to the quadrant elevation will be exactly one half of this angular measure of the cone at each range. Since, however, the problem is a question of *safe* clearance, a liberal estimate must be made of the size of the cone over and above that which would be expected from the data supplied in the Official Range Table. Under actual war conditions the 100% zone of the 18 pdr. gun, even under the most favourable circumstances, will generally average at least 25% greater than the figures given in the Range Table, and hence it will be necessary, in order to allow a safe margin in determining the angular measure of the cone, to base the calculations upon 50% greater 100% zones than those given in the Range Table. These results can now be tabulated as follows, together with the data upon which they are based:—

RANGE.	100% ZONE (50% greater than R.T.)	5′ ELEV. ALTERS POINT OF COMPACT.	½ ANGULAR MEASURE OF CONE, TO CLEAR LOWEST TRAJECTORY.
1,000	72 Yds.	58 Yds.	3 mins.
2,000	132 ,,	44 ,,	7½ ,,
3,000	186 ,,	35 ,,	12½ ,,
4,000	238 ,,	30 ,,	18½ ,,
5,000	270 ,,	26 ,,	25 ,,
6,000	300 ,,	23 ,,	32 ,,

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The right hand column of this table thus represents the "safety" angle which must be added to the quadrant elevation to the crest at the various ranges in order to ensure that the lowest or shortest round of the cone will safely clear the obtruction. A comparison of the 3 mins. at 1,000 yds. with the 32 mins. at 6,000 yds. will serve to emphasize how comparatively *small* this angle really is at short ranges.

Now the rule suggested by Lt.-Col. Hill is as follows: "*The safe clearance in minutes is found by halving the number of hundreds of yards in the range to the target.*" By referring again to the right hand column in the Table above, it will be seen that this rule renders a fair enough approximation to the actual figures to be quite applicable for all ordinary purposes. The exception I take to the rule, however, is that the safe clearance does not depend necessarily upon the range to the *target*, but rather upon the range to the CREST. Unfortunately the only example which was supplied to illustrate the rule was one in which the range to the crest was for all practical purposes the same as the range to the target, and hence under these conditions the rule was of course quite applicable, and its limitations were therefore not evident. But suppose, (as in Fig. 2, on a previous page) that the range to the crest were 4,000 yds. while the range to the target 6,000 yds. According to the rule, a safe clearance of 30 mins. would have to be allowed, whereas the actual vertical width of the cone where it passes over the crest of the ridge is such that only a clearance of 20 mins. (corresponding to a range of 4,000 yds.) is needed. Hence there is 10′ of elevation still to spare, and by lowering the elevation of the gun by this amount it would be possible to engage a target approximately 50 yds. nearer—which, by the way, might be of considerable importance to the success of a military operation. The extent of this unnecessary clearance above the crest of the ridge in the case in question is clearly indicated by the drawing in Fig .2.

Of course I do not claim in the least that the rule as given by Lt.-Col. Hill is not a *safe* rule to follow, for, as a matter of fact, if I may put it in this way, it is really *too* safe a rule, and this is just its fault, since it overestimates the clearance that is actually necessary in every case where the crest or obstruction is anywhere but near the target. If the rule means anything at all it is meant to indicate more or less definitely the safe limit in clearing a crest to which one may lower the elevation of the gun in order, by a process of creeping back, to engage some *special* target. No Battery Commander would conceivably undertake, for instance, to lay on his "Night and Day" lines with only such small clearances for there are so many additional errors which may creep in at any time that the consequent effect of these errors would not be noticeable until the first few rounds had been fired at the next time of opening fire—when of course the damage would already have been done. Hence it must be evident that the rule, to fulfil its real purpose, should indicate more or less accurately this safe limit—and no more than this safe limit—for whatever the range may be to the *crest*. Now it is very probable that the character of the terrain in Northern France and Belgium is such that seldom will a case be found where the trajectory of the 18

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pdr. gun at normal ranges will not easily clear the obstruction, when such obstruction is somewhere midway between the battery and the target, or at least within a 500 to 1,000 yard limit of this. But, on the other hand, cases will often occur when the obstruction is either near the target end of the range, or, on the other hand, near the battery end, and in these cases it will often be necessary to determine the safe clearance quite accurately.

It will be evident that particularly in cases where the obstruction is near the battery end of the range (for instance at 1,000 yds.) the safe clearance if based upon the range to the target instead of upon the range to the obstruction, will be very misleading and greatly over-estimated. A case in point actually occurred to the knowledge of the writer in the Canadian attack on Vimy Ridge. Following the attack when the batteries moved forward to positions nearer the Ridge it was necessary for one battery in particular to move up very close behind a steep part of the Ridge in order to escape hostile observation from a flank. This battery was subsequently called upon to engage a nest of machine guns in the open, which allowed a very small clearance over the top of the Ridge. The range to the target was about 3,300 yds., while the range to the crest was only a little over 1,000 yds. Now if the safe clearance had been based upon the range to the target instead of the range to the crest (in other words, 15 minutes of clearance instead of 3 minutes) the Battery Commander would not, under the circumstances, have dared to engage the target, for to do so it was necessary to lower the elevation of the gun until a clearance of only 5 minutes above the crest remained. However, by careful laying the target was actually engaged with success, with only this small amount of clearance. In other words, the extra 10 minutes by which the elevation of the gun was actually lowered below the margin of safety of 15 minutes as based upon the range to the target, made it possible to engage a target 75 yds. *nearer* than would otherwise have been attempted on the strength of Lt.-Col. Hill's rule. This case in point, having been actually experienced during a very important attack, will serve I hope to explain the reason why I have gone to such pains to point out the limitations to the rule. Even if in such cases —where the obstruction is at the battery end of the range—one were to resort to the common practice of levelling the clinometer at zero and looking through the bore of the gun to determine the safe clearance, it will be evident that the results would be equally as inaccurate for this method can only be depended upon when the obstruction is within a few hundred yards only of the gun position. I would therefore suggest that the rule be changed to read as follows:—*The safe clearance in minutes is found by halving the number of hundreds of yards in the range to the CREST.* It should be borne in mind, however, that the clearances indicated by this rule, which are based upon 50% greater 100% zones than given in the Range Table, can be safely depended upon only under conditions of very careful and accurate laying carried out by well trained and reliable gun detachments and in addition a careful assortment of ammunition. Otherwise it will be well to count on at least 5 to 10 minutes extra clearance in each case to avoid any possible trouble—the former when the crest is

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at the battery end of the range, the latter when it is farther away or near the target.

A further caution I would like to point out in regard to the application of the above rule. When determining in the first place the respective quadrant elevations to the target and to the crest in order to compare these, the question might arise as to whether that portion of the quadrant elevation which represents the angle of elevation of the gun corresponding to the range to the target or crest, should not be based upon the *map* range to these points, or, on the other hand, upon the "predicted" *gun* range under the particular conditions of the atmosphere at the time and the known M.V. of the gun which is to be used. In answer to this it may be laid down that in every case where it is necessary to determine the safe clearance more or less accurately, it is the "predicted" *gun* range which must always be used, both for the range to the target and to the crest. In certain cases of course—where the crest is near the target end of the range—it really matters very little whether the calculations are based upon map ranges or gun ranges so long as either one or the other is used in both cases, for the range to the target and to the crest. But in every other case, particularly when the range to the crest is small compared with that to the target, it may easily mean a serious error of from 10 to 20 minutes in the calculations if the actual gun ranges are not used. Of course, in any case, a rough approximation based upon map ranges will nearly always prove useful as a preliminary guide.

In conclusion, I would like to say a few words on the subject of *rules*, now that an opportunity has presented itself. It appears to the writer that in the complete absence of more suitable means for quick and accurate calculations, it too often happens that the Gunner Officer is forced to collect in his note book a great many so called "handy" rules—or worse still, attempt to commit such rules to memory—with the inevitable result that in actual experience they become more of a nuisance and a source of error than anything else, for in a great many cases the various factors which are co-related in these rules are so common to *all* the rules, and so similarly worded in each case, that it is indeed a difficult task to avoid the mistake of combining a part of one rule with a similarly worded portion of another. For instance, the use in quite different rules of such similar terms as—"halving", "quartering", "doubling"; "hundreds of yards", "tens of yards", "thousands of yards"; "in minutes", "in degrees", "in seconds"; and so on—all of these pet phrases are so similar, though in reality quite different, that it is very easy to make a serious mistake by confusing them in different rules, when attempting to make a rapid mental calculation. Moreover, in addition to these rules, there will always be a number of formulæ (of a more or less complicated character) which will form a part of the Artilleryman's note book for the purpose of solving some of the more difficult problems in gunnery when the occasion arises. In such cases it is necessary to resort to "pencil and paper" calculations together with the task of interpreting correctly the meaning of the various symbols and abbreviations as used in any particular formula—all of which is a decided inconvenience on the one hand, and a waste of valuable time on the other.

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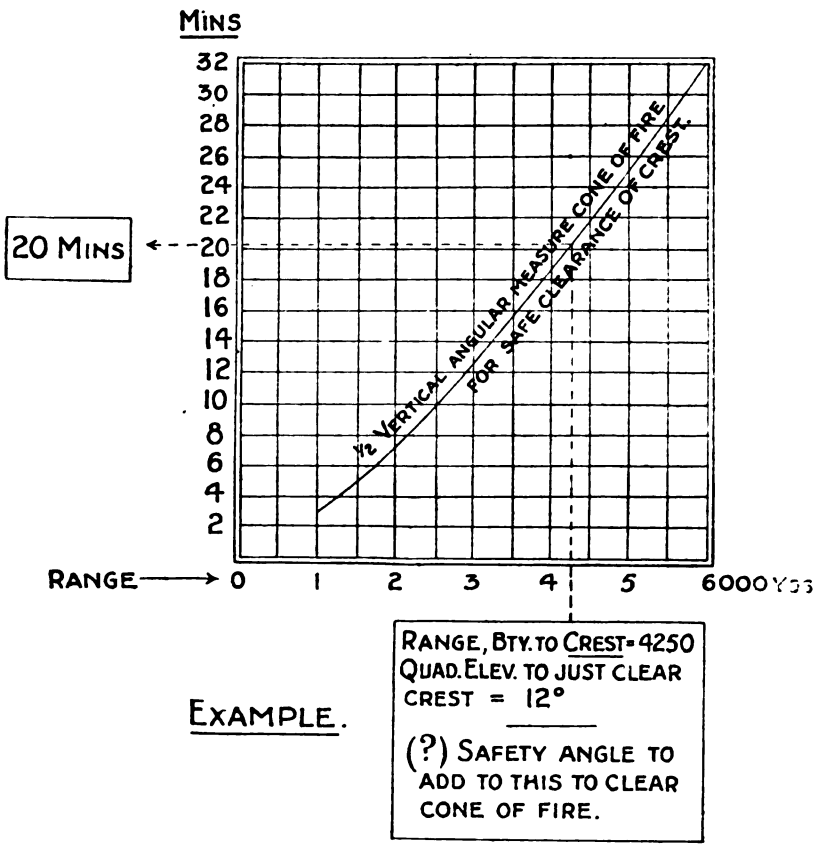
Now in contrast to either of the above cases, whether it be a rule or a formula, it is much simpler, and of infinitely easier application, to have each of these numerous rules and formulæ represented *graphically* by means of a characteristic "curve" in a graphical diagram, so that the result required under any possible condition of the problem can be read off *at once* from such a curve, and without the least possibility of error since there is no dependence whatever upon the memory or other mental effort of any kind. I would like to point out, accordingly, that this is exactly what the writer has endevoured to provide in a practical way in designing his new "Graph" Range Card for the 18 pdr. gun. The particular curve in this Range Card, for instance, which represents the rule for safe clearance which has just been discussed, is reproduced below for the purpose of illustrating my point.

FIG. 4.—SAFE CLEARANCE CURVE.



From the above diagram it will be seen how easily the safe clearance can be found at once for any range to the crest. For instance,

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suppose the range to be 4,250 yds., as indicated in the example shown in the figure. Pass the eye up the imaginary *vertical* line corresponding to this range (see dotted line) until a point is reached where the line cuts the curve, then run the eye from this point to the left along an imaginary *horizontal* line till the "minute" scale on the left of the diagram is cut at a certain point; this point will then indicate the answer, which in this case turns out to be 20 minutes. Hence 20 minutes is the safe clearance which must be allowed when the crest is at a range of 4,250 yds. Similarly, the clearance at any other range can be found in the same easy and rapid manner. Indeed, the diagram speaks for itself—and may I say, for the "Graph" Range Card of which it forms a typical part. Any further explanations by the writer are, therefore, unnecessary.

In the Field.
September, 1917.

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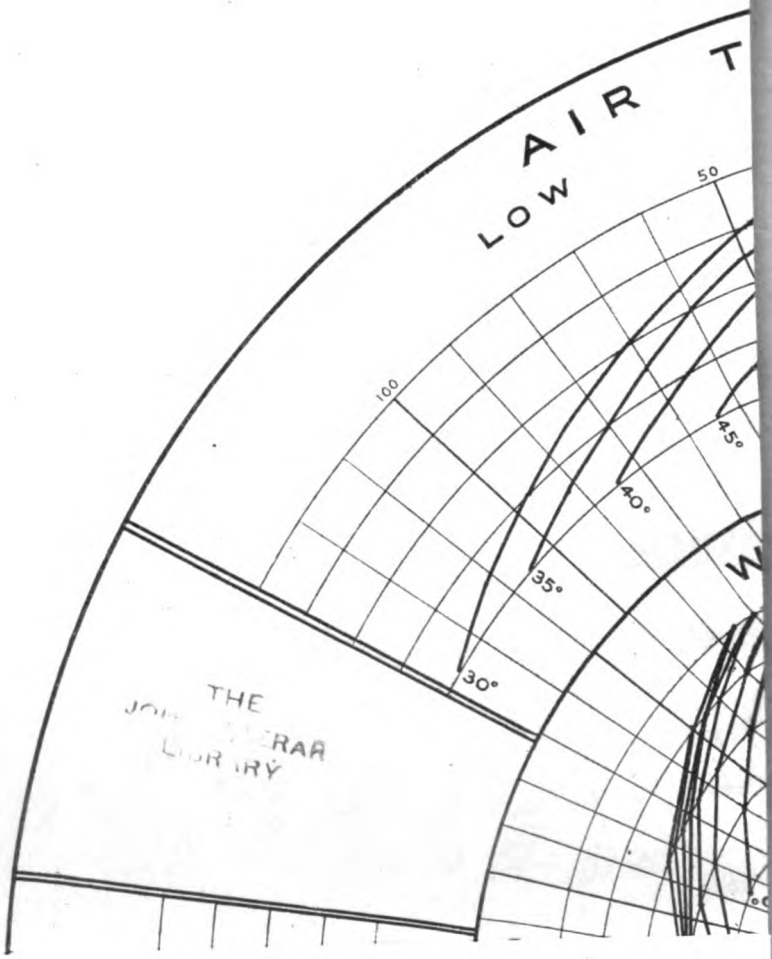

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THE DISC "METEOR."

By Capt. H. Brittain, R.F.A.

THE instrument consists of two concentric discs, the smaller being imposed on the larger.

A cursor or pointer is fixed by a pivot through their centres, stretching to the edge of the larger disc and fitted with an arrangement for clamping it to the smaller disc.

Radii run out from the centre of the discs over the face of both of them, marking yards (10 yds. = 5 degrees).

Concentric and equidistant circles on both discs refer to the range at which the gun is being fired (2, 3, 4, 5 or 6 thousand yards. Intermediate ranges to be taken proportionally). Minus and plus corrections made on normal range are read on the right and left of zero line respectively.

On the inner disc are a series of graphs shewing corrections to be made for wind at the various ranges and for various angles of wind to line of fire; *e.g.* the correction at 4000 yds. for 30 f.s. following wind at 70° is given by placing cursor over intersection of 70° graph with 4000ᵡ circle and reading off range on inner circle viz: 30 yds.

Similar graphs are given on outer disc for various temperatures of charges (N.C.T. and Cordite) and Air, and Barometer readings.

To use the discs.—

E.g. conditions are as follows:—

Wind 30 f.s. following at 70° Barometer 29·0 ins.
Temperature Air – 55° Range 4000.
" charge (Cordite) 50°

(1). On smaller disc place cursor over intersection of 4000ᵡ circle and 70° graph. Correction read = – 30. Clamp cursor.

(2). Swing inner disc and cursor together till cursor is on normal Air Temperature line.

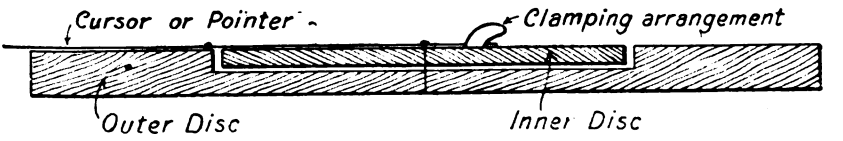
Unclamp and swing cursor on to intersection of 4000ᵡ circle and 55° graph. Clamp cursor again, now reading – 20ᵡ.

(3). Swing inner disc and cursor together till cursor covers normal line for Cordite Charges. Unclamp and move it until it lays on intersection of 4000ᵡ circle and 50° graph Clamp; reading is now ± 0.

(4). Repeat this for Barometer 29 ins. Final correction is – 40ᵡ. This is the correction for the particular day, for range of 4000ᵡ.

Deflection for Wind is given by scale on inner disc.

In elevation the instrument would appear as follows:



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A WIND CORRECTOR.

By Capt. G. P. Richardson, R.G.A.

THE diagram on the opposite page gives corrections and deflections for wind with sufficient accuracy for all practical purposes. It has been made out for the 18-pr. Q.F. Similar diagrams could be made for any other guns.

To use, point the arrow "A" towards the direction from which the wind is coming. Then draw a line from the centre of each circle in the direction of the line of fire to the Range as indicated by the circles. The dotted lines on the upper diagram indicate the factor by which the wind velocity in f/s must be multiplied in order to give the correction for wind in yards. The lower diagram used in a similar manner gives the deflection for wind in minutes.

Example.

A wind of 30 f/s at an angle of 40° to the line of fire and from Left to Right. Range to Target 4500 yards.

The position of the target relative to the direction from which the wind is blowing is at B. From the upper diagram the factor is 2·6. Correction for wind is 30 × 2·6 i.e. + 78 yards.

From the lower diagram the deflection factor is ·7 Left.

Deflection for wind is 30 × ·7 i.e. 21 minutes Left.

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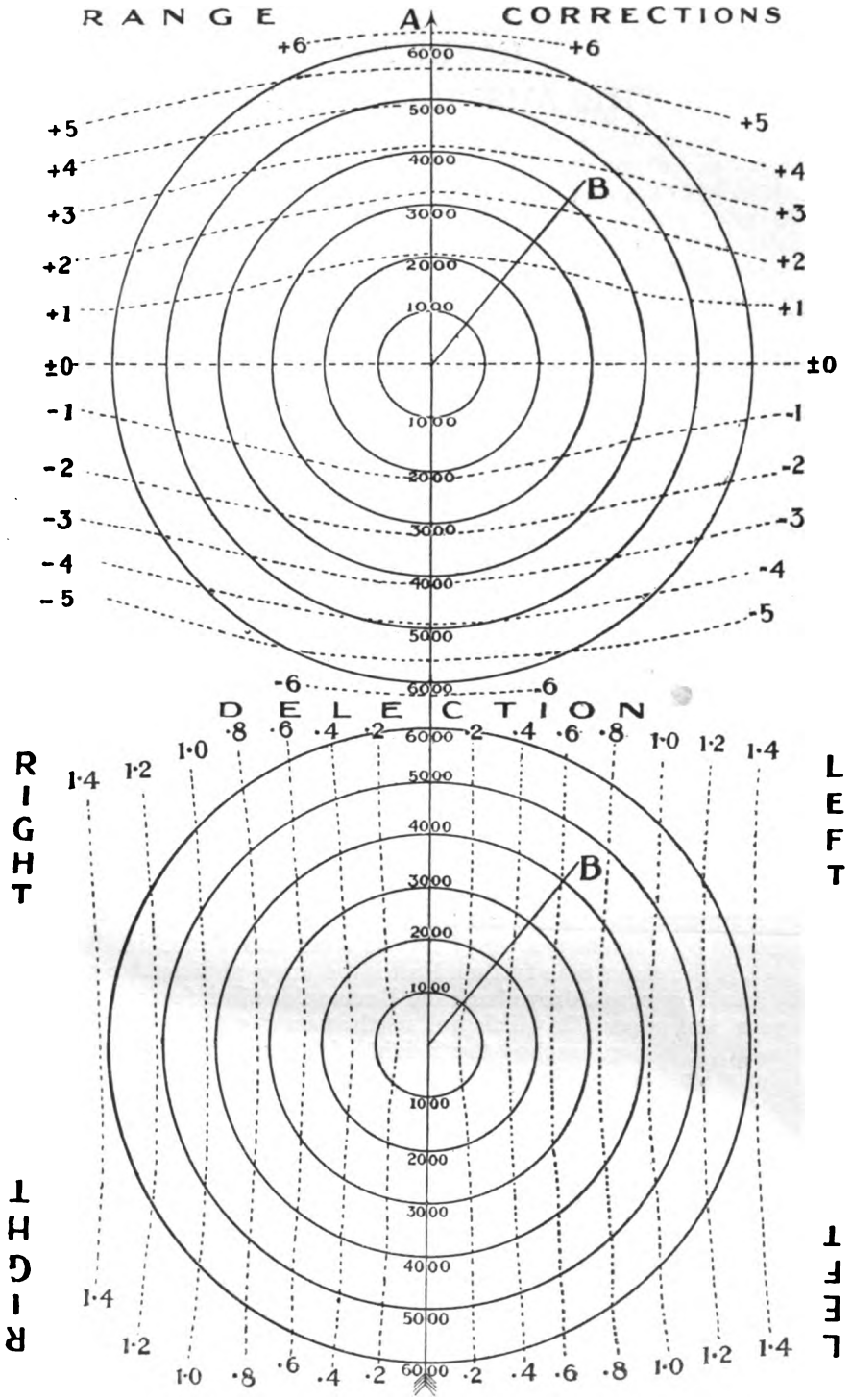

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IMPRESSIONS FROM THE AUSTRO-HUNGARIAN FRONT.

VII.

(Translated from the "Revue Militaire Suisse".)

By Captain G. de L. Landon, M.C., R.A.

With the Army of Transylvania—The Roumanian Invasion—The wooded Carpathians.

In January 1917 the army of Transylvania, formed from the 1st and 7th Armies, extended along a front of 300 kilometres from the Oitos Valley in Roumania to the Tartar passage on the frontier of Bukovina It was then commanded by the Archduke Joseph whom we have already met in 1915 on the Izonzo in command of the 7th Corps.

For obvious reasons, I will avoid entering into detail as to the composition of this army. It was formed from very diverse elements, collected in haste in the autumn of 1916, when the offensive against Roumania was begun.

When at the end of August 1916, the Roumanian Army penetrated into Transylvania, there were on this frontier only two Hungarian divisions, 39h and 61st together with a few Landsturm battalions.

These troops, having destroyed the bridges and railways, withdrew fighting to the line Segesvar—Valley of the Maros—Szas—Regen, to give time for reinforcements to come up. The Roumanians advanced only with extreme caution. At the end of September the Austro-Germans were able to undertake their offensive. The battle of Hermannstadt forced the Roumanians to recross the Rotenturm, pursued by Falkenhayn who followed them into Vallachia.

At the same time further North, the army of Von Arz preceded by a cavalry corps, drove back the Roumanians in a few weeks to the line of the upper Alt which was reached on the 10th Oct. The 1st Cavalry Division reached the height of Gyimes on the Roumanian frontier and entrenched there pending the arrival of the main body. By the middle of October the Roumanians were flung back into Moldavia along their entire front.

It was at this time that the Russians made some tardy efforts to come to the aid of their Allies by vigorous offensives in Bukovina and the wooded Carpathians. The Roumanian divisions operating in Northern Moldavia were relieved by Russians at the beginning of November. The six divisions thus set free, could be transferred to the South. But the Roumanian Army were already too battered to undertake offensive action.

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At the close of November Falkenhayn commenced his movement on Craïova, and Bucharest fell without resistance on December 6th. The Roumanian retreat was accentuated by the continuous pressure of Mackensen in the South and the Archduke Joseph in the West. The army of Transylvania followed the Moldavian frontier, its right wing facing North-East with the intention of reaching the Trotus a tributary of the Sereth. It joined up in January last to the Army Group of Von Gerok, which in turn rested on the left wing of Falkenhayn's Army. The situation has remained practically the same on this front in spite of changes in the High Command. Further north in the Bukovina around the regions of Kirlibaba and Dorna-Watra the Russians multiplied their attacks in mid-winter in very rough mountainous country, sparsely inhabited and poor as to means of communication, where a tactical success bears no fruit and causes the attacker losses out of proportion to the results obtained.

The Army Commanders, Generals von Kovess and von Arz are two of the most renowned in the Austro-Hungarian Army. They are both Hungarians.

Colonel-General von Kovess commanded the army which accomplished the second Serbian campaign of 1915. He is of medium height, broad-shouldered, florid, and clean shaven and possesses a charm and geniality which go a long way to smooth his intercourse with the Magyars.

General of Infantry von Arz, who replaced Conrad von Hötzendorf as Chief of Staff to the army is a little man of extraordinary vivacity. His conversation is captivating—a running fire of wit; one is astonished before such learning, and breadth of view combined with great simplicity, charming bonhomie, and modest exterior.

Arthur Arz von Straussenburg was born in 1857 at Hermannstadt, Transylvania. All his service other than staff service has been with the infantry. When war was declared he held an important position at the War Office, but was at once given the command of the 15th Division, and in Sept. 1914 that of the 6th Corps.

This corps has become famous; the whole army knows the "Arz Corps" which has distinguished itself in a long series of brilliant actions, to mention only the battle of Limanova in which von Arz on the right wing of the 4th Army, thanks to his prompt grasp of the situation exercised a decisive influence on the result of the battle. Limanova might be compared to the Battle of the Marne in that it was the first stroke towards the regaining of the territory lost, a turning point in the history of the Austro-Russian campaign. Thence forward, from May 1915 to the capture of Brest—Litowsk he took part in the rapid and victorious offensive against the Russians in Poland.

When the Roumanians invaded Transylvania, the Emperor entrusted Von Arz with the 1st Army made up of troops withdrawn from other fronts and depôt troops. As soon as the enemy had been driven back into his own country, he left his command, in the Spring of 1917, to take up the post of Chief of the General Staff.

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The most important points in the wooded Carpathian sector are, from North to South: the Tartar Pass or Jablonica which leads from the valley of the Theiss into that of the Pruth, the *massif* of Capul to the North of Kirlibaba, the strong point of Mesticanesti near Valeputna, and the heights on the left bank of the Bistriz, dominating Dorna-Watra.

Only three railways cross this mountain chain: one from Maramaros—Zsiget to Kolomea through the Tartar Pass, one from the height of Gyimes leading from the valley of the Csik to the valley of the Trotus, and the last from Dorna-Watra to Kimpolung, linking the Bistriz valley with that of the Moldava. A cross-line runs parallel to the frontier between Kronstadt and the Maros valley. All other lines are secondary and end in culs-de-sac.

Outside the principal valleys there are no carriage roads. Rough tracks follow the courses of the streams. The forests are impassable. unless paths are cut with axes.

The resisting power of the mountain itself to the heaviest shells is one of the most reassuring facts brought home to a Swiss on these fronts. Rock will stand the most violent bombardments, and reserves are able to rest in complete security. The artillery of the defence can act without hindrance and with the minimum of losses. In the Carpathians I have been over positions which have been exposed for weeks to the methodical fire of the heaviest guns without apparent effects on the surface of the mountain. Mountainous countries are formidable fortresses. The mountain is stronger than the gun.

Trench Warfare.

Density of front.

In December 1916 and January 1917 I went over the greater part of the front held by the Army of Transylvania. The extent of the front and the thinness with which it was held struck me at once; a company holds a section of defence for which before the war a battalion would have been considered barely sufficient. The proportion of one rifle to every yard of front is never attained. In January 1917 the 1st Army Corps held a front of 25 km. with 16,000 rifles; the 11th Corps one of 50 km. with 20,000 rifles; the 6th Corps 60 km. with 22000 rifles; the 39th German Reserve Corps 35 km. in the offensive. Many companies were responsible for 1 km. each I have seen a battalion of the 12th Division, holding a front of 4 km. one of its companies occupying 1600 m. of first line trenches and successfully repelling repeated attacks for weeks on end. The number of machine guns was increased at that time to four per company sector.

Reserves. To this thinness of front there corresponded an almost complete lack of distribution in depth. No general but only local reserves existed, one or two sections per company and, if possible, one company per battalion. This system is necessary in mountain warfare owing to the extreme slowness of movement. Lateral movements require a considerable time and distant reserves always arrive too late.

The reserves are kept in the second or third line awaiting the

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order or the opportunity to act. During the bombardment preceding an assault the first line troops take refuge in their dug-outs six metres at least under ground, and only reoccupy their trenches at the moment when the assault commences.

As the Russians generally attack only a limited piece of front, in order to capture a salient or strong point, the reserves of neighbouring sectors are brought up behind the one attacked, ready to intervene if necessary.

If the attack is successful, the second line serves as a rallying line and jumping off position for the counter-attack. The neighbouring sectors subject the captured positions to flanking fire from their machine-guns.

In the case of the loss on a wide front of the two or three lines forming the first system of defence, the troops retire on a stragetical rallying line prepared in advance. This second position is prepared by men of the auxiliary services (Arbeiter Kompagnien) assisted by the engineers. The artillery of neighbouring sectors always assist in the defence of the sector attacked. Mountain guns either singly or in two's render considerable service as flanking guns.

Outposts. Often as much as 2 km. separates the two hostile front lines. There is accordingly a regular system of outposts, a kind of advanced line. Beyond this line the field is free for the operation of patrols.

There are in each company sector a certain number of N.C.O's posts about 300 metres out, linked by telephone to the company commander. These posts send small patrols a short distance out in front. In very broken ground there are as many as four posts per company, at intervals of from 50 to 300 metres. By night there is continual communication between posts by means of patrols.

Listening posts (Horchposten) by day in front of the obstacles, by night behind them. These are not sheltered but hidden or camouflaged.

In the trench there is one sentry per section.

Russian method of attack.

The Russian attacks are generally preceded by a dense curtain of patrols whose mission it is to drive in the outposts.

Late in the afternoon the artillery preparation commences. Its first objective is the destruction of the obstacles; but last January the Russians appeared to be husbanding their ammunition, for they did not always succeed in destroying the obstacles sufficiently thoroughly. They also sought to make breaches with their trench mortars.

Then comes a concentrated fire on the first line trench. The Russians employ a procedure which the Austrians call "Punktschiessen", that is a regular and precise fire for several days on the same points, as for example, machine gun emplacements, flanking guns, trench mortars, and dug-outs. The moral effect is greater than that of "drum-fire." This bombardment continues throughout the night until midday on the following day.

Meanwhile the infantry advance to between 300 and 500 metres

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from the position to be captured and dig themselves in under cover of darkness.

At the moment fixed for the infantry assault the Russian artillery lengthens its range to include the reserves, neighbouring sectors, and the artillery positions of the defence. The field guns continue to spray the first line trenches, until the assaulting waves reach the obstacles and capture the trench.

From this moment these batteries endeavour to anticipate counter-attacks by the reserves of the defence, in order to allow their own infantry to consolidate the position won.

The Russians advance in successive lines of skirmishers, with from 150 to 300 metres between each line and the one behind. The first wave carry wire-cutters and hand-grenades but no rifles, and is generally mown down. The succeeding waves often have machine-guns with them. The 6th or 8th wave may penetrate the trench according to the state of the defenders' morale and their losses.

Even if the attack is launched on a front of several kilometres, it is perforce broken up and "canalised" by the mountainous nature of the ground, and only reaches the more advanced portions of the defence. It is thus difficult for the attacker to avoid being taken in flank.

If the attack fails the artillery preparation recommences and a second attack is launched the following day.

The infantry attacks take place in daylight as, owing to the difficulties of the ground, a night attack loses all cohesion.

Barrage fire during an attack hinders the movement of reserves. At other times when the routes in rear of the front are filled with transport, replenishment of supplies is considerably inconvenienced by it. I have on two occasions been amongst transport columns coming under barrage fire six kilometres behind the line. There was no panic or disorder. The drivers, for the most part civilians, ran to their horses' heads and led them quietly off the road.

System of fortification in mountainous country.

In mountainous country the site selected for a defensive line should take advantage of the varied nature of the ground, mitigating the weakness of some points and reinforcing the natural strength of others. There are so many dead angles, flankings, and deep ditches or chasms, that there results a system of broken and terraced lines of trenches with numerous salients. In some parts the front may be continuous whilst in others isolated works will suffice.

The infantry have learnt to do without the help of the engineers. Work which was formerly reserved for the technical branch, they now carry out themselves. Trench making is an excellent school; one sees everywhere footbridges, hutments, tracks, and strong points which have been made without the aid of a single sapper.

Nevertheless it has been found necessary to create in each regiment of infantry one pioneer company ("technische kompagnie") recruited from the infantry but specially trained in technical work and equipped with special tools. The upkeep of the roads behind the

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front is left to the auxiliary services (Arbeiter Kompagnien) assisted by prisoners.

As we have already seen, a *position* (Stellung) consists usually of two or three lines, 100—300 metres apart, and strong points.

These lines are made simultaneously, the reserves working on the 2nd and 3rd lines.

The first is, to start with, only a line of outposts gradually linked up into a continuous line. When the ground is favourable (rocky with deep chasms) mutually supporting strong points are sufficient.

The front is broken on principle, thus increasing the opportunities for flanking fire.

The system of self-supporting strong points, abandoned in 1914 and 1915, has been readopted in 1916. In the mountains such works, occupied by one or two companies with machine-guns, can render valuable service. For example, the *point d'appui* of the Mesticanesti tunnel on the railway between Dorna-Watra and Kampolung, in the Bukovina, has held out for eight months against all Russian attacks. Repeated bombardments levelled the works on the summit, and the shelters cut into the rock in the gorge alone remained intact. As soon as a bombardment starts the little garrison takes refuge with its machine guns in these shelters. When the assaulting columns become visible the defenders re-occupy their positions and open fire. Up to the present the Russians have not succeeded in dislodging the handful of men holding this work, who are detached from a regiment of gendarmes well-known for its bravery.

The type of trench most commonly met with is narrow, without overhead cover, and with numerous broad traverses. It is about 2 metres below ground level with 4—6 metres thickness of parapet.

The trench must be narrow because the wider it is the more chance of ricochets into its interior. Also, the earth composing the sides has a tendency to fall into the trench, and the continual removal of this earth naturally widens it by degrees.

The trench must be open because overhead cover gives only a false security, being of protection only against shrapnel bullets and rain, limiting the field of view, and giving the men the impression of being shut in. In addition, if the enemy gained a footing in the trench, and the exits had been blocked by the bombardment, the garrison would be unable to escape.

In exceptional cases a section of trench which is enfiladed or otherwise commanded by the enemy is covered in, but the cover is more in the nature of a screen from view, or a camouflage, than an effective shield.

Machine gun emplacements are open to the sky, except amongst the rocks when there is time and means to hollow out a shelter. Loopholes are no more. Their regular shape rendered them visible from afar.

Sand bags are of temporary use only, that is in the early stages of trench construction, and among the rocks in high mountain country where earth is scarce. They are apt to burst in frosty

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weather or under sudden variations of temperature, and spill out the earth contained in them.

The bomb-proof shelters are 10—30 metres behind the front line and linked with it by communication trenches. These casemates can shelter from one to two sections (Kavernen) or a group (Fuchslocher). There are always two entrances. Six metres of earth and stones, arranged in three layers separated by timber, is considered the minimum cover.

Communication trenches connecting the first line with the other lines are zig-zag and without overhead cover.

Obstacles. The large number of natural obstacles existing in the mountains strengthen the positions and simplify the creation of *artificial obstacles.*

Those generally employed are barbed wire entanglements and rock avalanches. The use of *abattis, fougasses,* concealed pits, and mine fields, is exceptional.

The obstacle zone is sometimes divided into several lines, the number and depth of which depends on the ground. Generally the obstacles commence about 50 metres from the trench and extend to a depth of 50—100 metres. In forest felled trees are useful to support the wire entanglement.

Chevaux de frise are much employed, being made on the spot by the reserves. Thrown out in front of the positions they serve to fill up gaps, to re-establish rapidly a line of obstacles destroyed by bombardment, to cover the construction of a trench, and to close the gaps left for the issue of patrols.

Lines of barbed wire at right angles to the front are placed in the dips between spurs, forming compartments in which the attacking troops are "canalised" and subjected to enfilade fire, if they succeed in getting through the preliminary obstacles.

Plain wire is often employed stretched between very short pickets (20 or 30 cm.) and hidden in long grass, loose gravel, or snow.

The distance between the opposing lines does not permit of sapping operations, and the rocky soil and steep slopes render mining operations very long and arduous.

Paths and roads visible to the enemy are screened for considerable distances. *Camouflage* is accomplished by means of wooden arches covered with leafy branches when the path is enfiladed by the enemy, but when it runs parallel to the front, wooden palisades from 4 to 5 metres high are erected on the enemy side.

Transport.

The Austrian Army has adopted as a universal model a peasant's cart of the country which has stood all tests since the beginning of 1915. It weighs about 2 cwt., is drawn by two horses, and driven from the box. The span of the wheels is 40 inches and its maximum load is 4 cwt. These vehicles were requisitioned at first, but are now made by the Government.

Dogs are coming into use as draught animals.

In the Carpathians an infantry battalion has 120 pack horses and 12 baggage wagons. For barbed wire first line transport is employed,

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but besides this each infantry regiment has 15 wagons loaded entirely with wire.

There are also small two-wheeled carts in the first line transport, similar to our machine gun carts.

Equipment and Matériel.

Winter Clothing. Special equipment is required to face the low temperatures prevalent in winter in the mountains. In our army the soldier is not clothed for winter campaigning. Everything is calculated on the assumption of a summer campaign. The Austrian soldier is issued with woollen vest, drawers, and socks. The great-coats and cloaks are provided with a detachable lining of flannel or fur. The soldier is also provided with a sheep skin waistcoat worn underneath the tunic and a grey woollen cap and gloves.

Sentries, scouts, and observers wear a fur cap, a *pelisse* extending down to the feet on top of the great-coat, a muff slung from the neck, and boots of plaited straw lined with wool over their marching boots. Thus they avoid the mortal effects of a temperature as low as 25°—30° below zero in the Carpathians.

Head-gear. The linen cap of the Austrian Army has great advantages, a soft form of head-gear being the only one practicable in the mountains, where it is absolutely necessary that the cap should fit securely on the head. In a difficult place an abrupt movement to retain his képi or helmet may cost a man his life. Mountaineers and tourists have never worn a rigid head-dress. It is urgent that we should adopt some soft and light form of head-dress for our mountain troops.

Puttees. Adopted throughout by the infantry they have come successfully through the tests of three arduous winter campaigns. On the other hand they have been given up by the cavalry after several unsuccessful trials. The latter now wear long boots with iron soles.

Puttees have serious drawbacks for mounted troops. They quickly wear out and easily come unrolled, especially in the case of artillery and transport drivers. The leather gaiter is infinitely preferable.

Travelling ovens. In the war of position the travelling kitchens are brought up as close as possible to the firing line. Fatigues come back to them to fill up their travelling ovens, with which every unit is now provided. They are the only means by which the troops in the firing line can be supplied with hot food, and the fatigue parties prevented from spilling the soup en route.

Aerial tramways. These assure the transport of munitions and food to the most elevated positions. There was one per regimental sector in the 40th Division. They were set up very simply with the materials to hand; the cable running round a big wooden wheel fixed horizontally at either end, one horse supplying the necessary motive power.

Necessity has greatly developed the practical nature of the troops. The men have become "jacks-of-all trades" and can assure themselves a modicum of comfort under all circumstances.

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Notes on the Russians.

At the beginning of January 1917 the Army of Brussilof consisted of the 8th Army (General Kaledin) and the 9th Army (General Letchinski). The shortage of officers which I had already remarked in the autumn of 1915 had become greatly aggravated. It was very rare to find any officers among the dead or the prisoners. The assaulting troops were led by N.C.O's and one or two officers per regiment, giving the impression that the officers must be spared at all costs. In Russia, the replacement of officers is an almost insoluble problem, since there is no cultivated middle class. As in all the other armies, the officers of the original Regular Army have fallen *en masse* in the early part of the war; and they have been replaced in part by N.C.O's, often quite illiterate.

Employment of Cavalry in the war of position.

The Jacobeny, Dorna-Watra sector was occupied by several cavalry divisions which, having played their part as independent cavalry in October 1916, now fought in the trenches. These divisions are re-inforced with 12 machine guns per regiment and some Horse Artillery, and are so organized as to permit of putting in line the greatest possible number of rifles without impairing their efficiency as cavalry and detracting from their mobile character. When the war of movement ceases three out of the six squadrons comprising each regiment keep their horses close behind the line (Reiterabteilung) while the remaining three send their horses back into the interior where they are employed in agriculture. The men of the Reiterabteilung preserve their mounted equipment so as to resume their role as cavalry at any required moment. This prospect helps them to endure the monotony of trench life. A cavalry division can thus place 4000 rifles in line.

The men of the Schützenabteilung are equipped as infantry. The wear the Rucksack and puttees instead of long boots.

All preserve, however, the uniform and badges of the cavalry, the short Hungarian pelisse and the Brandenbourg dolman.

When mounted the rifle is carried slung, it cannot be fixed to the saddle.

The Divisional Cavalry are always employed as cavalry.

The arm will come out of this war with an increased prestige; the cavalry have shown that they can fight as well on foot as on horseback. Nevertheless the true cavalryman has a horror of the term "Mounted Infantry" which signifies to him infantry of inferior quality and mediocre cavalry. At present in Austria-Hungary, musketry instruction is given great attention in the cavalry depôts, but the place of honour is reserved for good horsemanship and the development of those qualities of endurance and dash which have always been the chief virtues of the cavalryman.

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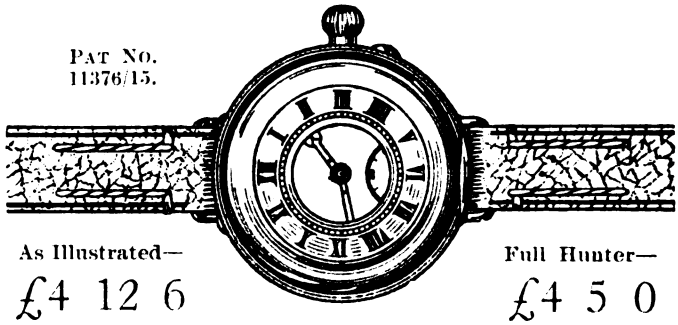

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HORSE MANAGEMENT.

A Lecture delivered at the Royal Artillery Institution, Thursday, January 3rd, 1918.

By Colonel A. S. Pratt, C.B.
(Inspector of Remounts).

Colonel P. H. Slee, R.A., in the Chair.

THE CHAIRMAN: Colonel Pratt has kindly come down here this afternoon to give us a lecture on horse management. A good many of you know as much about a horse as does Colonel Pratt, but there is scarcely anyone who cannot pick up a wrinkle or two by listening, and a good many of you have not had much experience. I hope you will all pay the deepest attention to what Colonel Pratt has to say.

COLONEL PRATT: As Colonel Slee has told you, there may be many present who know as much about horse management as I do. Those of you who have such knowledge must bear with me while I give my lecture so that others may benefit.

First of all I propose to deal with the question of mules. They are very good animals and everybody is liable to get them. As long as you are absolutely quiet with them you can manage them. They are very nervous animals and you must not shout at them. They are very obstinate animals, and you must be quietly obstinate with them and then you will find they will do anything you want them to do. I have in mind the case of a man who knocked a mule about. The mule waited for him three weeks caught him unawares and broke his leg. Those are rather the lines on which mules go. One of the first things to remember in connection with these animals is that you must be kind and quiet. If you want horses to do well and look well and work well you must be absolutely kind and quiet with them. Make friends of them and pat them, and you will find they will do very good work for you; knock them about and they will not work well. Then I must impress upon you not to play with them. Many men are in the habit of pinching them and tickling them, the result being that the animal says to himself, "Hallo, here is the thing coming to bother me and tickle me, so I must defend myself." Then the animal commences to bite and kick. If a horse begins to bite and kick you may rely upon it he has been taught to do so by being improperly treated by somebody at some time or other. Officers and Non-commissioned Officers should at once stamp out all signs of playing with these animals, because sooner or later such playing will turn to vice, and it will be a difficult thing to get them right again.

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Then there are one or two peculiarities about mules and horses. Mules are more particular about their water and less particular about their food than horses; horses are more particular about their food and less particular about their water than mules. This is pretty sure to happen to a good many of you before the war is over, that you will have to water a mixed force of horses and mules at a river or pond where the animals have to go in to drink. In such cases always remember to water your mules first. Horses do not mind so much the water having been stirred up. You will probably know that it is absolutely necessary for all these animals, whether mules or horses, wherever you are, to have as much water as ever you can give them at all times. You cannot over-water but you can very easily under-water. What are we trying to do now with horses and mules? We are trying to get the animals fit for service in the field either overseas or in England. What sort of animal is going to suit you in the field? Not the animal that has his ribs showing, poor lines down his quarters, and all split up behind; he will last you about a week or two in the field because you do not get your food and water as regularly as in the camp or barracks. What sort of animal do we want in the field? We want an animal on what we call the big rump side. If you lift his tail up it should look as if he has got a good big pair of well filled breeches on. That is the animal that is going to last you in the field because he has something to go upon in himself. How are you going to get this animal on the big rump side? You are going to get him by very careful attention at all times to four principal things: the first is watering, the second is feeding, the third is pace, and the fourth is grooming.

WATER.

I always put water first because I consider that water is the important thing, far more important than anything else. It is a very funny thing, but watering is often forgotten. People do not forget to feed but they often forget to water. Men often go out on fatigues with half a feed and forget to water. Nobody knows how long a fatigue is going to last, and so, when animals are sent out on fatigues, buckets should be sent out to water the horses before feeding. I saw a man the other day take two horses to water and they were very thirsty indeed. One of them finished first and put his head up in the air. The other one was very thirsty and he went on drinking. The man got hold of the head rope and got a steady pull on him and in time got the second horse to put his head up, and the man at once took him away. I said to him, "Do not take that horse away yet as he has not had nearly enough water." That horse drank at least another bucket full of water before he went away. That horse was systematically water-starved by a driver who did not understand the importance of letting a horse have as much water as it wants at all times. His stomach was all up; his coat was all wrong; and in fact he was systematically "water-starved." What I am driving at is this: when you take animals to water for goodness sake take time over it. Let the horses look about them; let them swish their tails; and if you will only give them time its a hundred to one that down will go

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their noses again, and every drop that they can get down into their stomachs the better for them. That is one of the reasons why we always superintend watering. We always ought to have an Officer and an N.C.O., if possible, superintending the watering; it should never be independent. No horse or mule should be moved till every animal has finished watering, because the moment you move one horse the other horses have their heads up and you cannot get them down again. We generally water about three times a day in the winter, and we ought in the summer to water four or five times a day or even six times a day; and they need water late at night when the weather is hot. When you have had a good sweat anywhere you want an extra drink at night, and it is exactly the same with horses. There is one thing to remember about watering, and that is, never offer animals water within say three-quarters of an hour after they have finished feeding, because if you do you may give them colic. I do not say that you will give them colic but you may do so if you do that. Always allow as long a time as possible, and then you will not run the risk of colic from that cause. I was going round a unit some little time ago—a heavy Garrison Artillery unit—and they had four sub-divisions in it. The horses in three of those sub-divisions looked pretty bad, and the horses in the other sub-division looked uncommonly well. I happened to be going round with the Sectional Officer and I said to him, "How do you account for the horses of this sub-division looking better than the horses of the other sub-divisions?" He replied, "I think I know the reason," and I asked "What is it?" He said "I have a very good sergeant there." I inquired what that sergeant did that the others did not. He said, "When he has got a horse that is a bit thin he is always watering it, and when it is cold he gives it chilled water." One thing about water that has struck me in this frosty weather is that some people bank up their troughs with manure right along the trough. I think it is a very good thing to do because it makes a sort of hot bed and keeps the water warm, and stops it from freezing, and the water is much better for the horses than cold frosty water. Of course you have to invent a good way of doing it so as not to stop the outflow and things like that.

FEEDING.

Then the next important thing is food. If you want animals to do well you must feed them "little and often." You must not give them great feeds because they cannot digest them. They should be fed regularly. If you feed them at certain hours in the day, try and do it regularly. It is well known that 3 lbs. of corn, hard stuff, maize, oats or whatever it may be, is quite enough for the ordinary animal to digest at a meal. When you have 10lbs of corn it is much better to feed it in four feeds than in three feeds. When you come to heavy horses where you get 15 lbs of corn it is far better to feed them five or six times a day. The great secret is to give them little and to give it them often. To carry that a bit further when you are on service give your animals as good a breakfast as you can and fill your nose-bags as full as you can and hang them on your animals and away you go. Probably at about 9 o'clock in the morning somebody will

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say, "Do you not think we had better feed the animals now?" That would be a very good thing to do, but do not do what I have very often seen people do. I have seen them put the nose-bags on at say 9 o'clock in the morning and leave them on, and perhaps they might have 5 or 6 lbs of corn in them. Some of the horses will eat the lot and some will not, but will mess it about, and will make such a mess of it that the next time you put it on they will not look at it, and you are wasting it. Put their nose-bags on by all means at 9 o'clock in the morning and leave them on, but let them have one-third of it; wait two or three hours and let them have another third and so on. In that way you will get through three-quarters of the day with a little something in the animal's stomach. What do you do yourselves on service? You get as good a breakfast as you can, and then put a crust of bread or chocolate or anything in your pocket and have a nibble at it occasionally. If you will do that with the animals and yourselves on service you will neither of you get in late at night with that great big hole in your stomach. I have proved it on service where I had very hard work for animals to do and very little food to give them. I got over the difficulty by giving them about a handful at a time, and, of course, by taking advantage of every drop of water I could get along the road.

Now, about crushed food, wherever you go, you will sometimes find a corn crusher, properly used it is a very useful thing indeed; but improperly used it is a very bad thing. "Never feed entirely with crushed food except in very special cases, which may be called veterinary cases," because if you feed entirely on crushed food what will happen is this, that the animal will get used to the crushed food and his gums will become soft, and when you send him away from here where he cannot get crushed food and he is put on to hard food, the hard food very soon makes his gums sore, and he will not masticate his food, and therefore he will get indigestion. If you have got a horse on the poor side it is a very good thing indeed to give him some crushed food, half and half, and then drop it to one-third crushed and two-thirds hard, and then gradually get him on to hard food altogether. If you send horses overseas that have been fed on crushed food they will bolt the hard food because it hurts their gums to masticate it, and very soon suffer from indigestion. The reason for their falling away will be that they have been fed on crushed food.

MAIZE.

We have sometimes to feed them on maize because it is a question of the supply of food; we have to feed on what we can get. Now maize as you know is generally fed in the crushed form and when it gets wet it swells. The result is that it swells in the animal's stomach. Therefore always soak maize well before you feed it, or it will swell in the animal's stomach and give him indigestion or colic.

CHAFF.

With regard to chaff a great many people do not think that chaff is much good, especially straw chaff. The answer is that it is bulk you want in the animal's stomach. I have always fed carriage horses,

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hunters &c. with a certain amount of straw chaff and a certain amount of hay chaff just to get bulk in their stomachs. Chaff starts the saliva and the gastric juices and helps the animals to digest their food. Sometimes chaff becomes very dusty and musty. Could you eat a pound of biscuits without something wet to help them down? Of course you could not. It is exactly the same with animals. The best thing to do is to put the chaff on a tarpaulin and turn it over and damp it with salt and water, but do not over-do it. Damp it so that when you put your hand in the chaff it just sticks round your fingers; and it will help them to digest their food very much. Of course you generally give the bulk of the hay at night and a little in the mornings. It gives them a foundation for the next feed they are going to receive. Take remounts. You do not know what they have got in their stomachs, as they pass through Remounts we try and get their stomachs right as far as we can. We in Remounts are able to get a certain amount of bran and linseed and so on; you cannot jam a lot of corn into them at once. It is a very good thing to sacrifice some of the remount corn at first and give them extra hay and blow their bellies out. When you have got their insides right you can then begin to shove the corn in and then it will put the flesh on.

PACE.

The next point I wish to deal with is that of pace. There is an Army Council Instruction, that came out in 1916, about the care of horses and pace. It says amongst other things that "The training of a unit should be so directed as to render it efficient and fit for service in every particular including its animals. The instruction of the personnel should be carried out well within the capacity of the horses both from the point of view of pace and mileage. It should seldom, if ever, be necessary to exceed the pace of the regulation trot." Now the pace of the regulation trot is eight miles an hour. It is not half as fast as a great many of you people think. If you measure out half a mile on the Common and you try and trot at that rate you will find you are trotting a great deal faster than you think eight miles an hour is. Any horse that can trot at all can trot at that rate. Men often seem to try and get the horses to trot as fast as they can and the result is that some horses are galloping. All fatigues should always be at a walk and they generally are at most places.

GROOMING.

The next important thing is grooming and whisping. Grooming and whisping circulate the blood and keeps the animal in health. Good grooming keeps away lice. We never used to have lice before the war. We get Remounts from all sorts of places and it is up to you to get them right. Then there is another thing in connection with grooming and that is the question of cracked legs and heels. What is a cracked leg and a cracked heel? A cracked leg and a cracked heel is very much the same as a chilblain to you and me. We get our feet and legs and hands wet and cold and the blood stops circulating and we get a chilblain that tickles and breaks. How are

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you going to stop that in the case of horses? You can stop it by always paying great attention to drying the legs and heels. I know that we have not got any straw now. I have tried to get a little straw issued to every unit for this very reason, to dry these legs and heels. But if you have not got straw you have always got hands and you must make the men get down and rub under the fetlocks as hard as they can, and rub the legs from the fetlocks to the knees and to the hocks, as hard as they can, and start the blood coming from the heart down the arteries and back to the heart up the veins and so get the blood circulating round and round the animal's body down to the tips of his toes. If you will put in a quarter of an hour at evening stables at that it will be about the best quarter of an hour you can put in, and you keep away cracked legs and heels. If men will pay attention to drying legs and heels they will hardly ever get a cracked heel at all. There is another thing. Horses are bound to sweat. Make your men look after them then. The other day I was going round a unit about a quarter to four o'clock in the afternoon and I saw one of the horses there looking all sweatty. I asked "What have you been doing with this horse?" They said, "This horse has only just come in." I asked, "Who has had him?" The reply was "A mounted orderly." I inquired "When did he come in?" and he replied "About a quarter of an hour ago." I asked "Where has he gone?" he replied "To his room." I asked "What has he gone there for" they told me "I suppose he is coming back to stables about half-past four," and the horse was simply dripping wet. That man had brought in a horse all of a muck sweat with all the pores open and he was just "hanging up to dry". If you do things like that it is a hundred to one something of this kind will happen that in two or three days someone will come and say, "We cannot get No. 23 to eat to-day, Sir." The officer will ask "What is the matter with him?" The answer will be I do not know; I think he has got a touch of fever; his head is all down and his eyes are all shut up and he will not look at anything; I suppose he has had a bit of a chill." Nobody ever knows how he got the chill, but he got the chill a few days ago because somebody "hung him up to dry." The very best thing is to groom him at once and dry him; walk him about in the air and dry him, throw a rug over him &c. We lost many horses at the beginning of the war because people would not look after them when they were hot. Those are the four principal points.

MISCELLANEOUS.

I have a few more points that I would like to make which I might put under the head of miscellaneous. First of all wherever you are you always have a certain number of horses on what we call the "hide bound side." They are just like us; we go out in the east wind and get our livers out of order and want something to put us right inside. The horse and the mule are exactly the same. Whilst going round some stables the other day I saw a horse looking very wretched, and I said "What are you doing with this horse he looks pretty bad." The answer was, "Well, Sir, we are giving him double the amount of

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food that any other animal in the stable is getting." I asked if it was doing him any good, and was told "No, we do not think it is." I asked, "Have you had a look at his teeth?" and they said "No." I said, "The very first thing when you see an animal looking like that, and his food is doing him no good, is to look at the back teeth and get hold of the A.V.C. Sergeant and it is a hundred to one that if he is a horse of say 9 years of age or over, he will have his back teeth jagged and sharp, and when he eats the sharp edges cut his gums, and he does not like masticating his food, bolts it whole, and gets indigestion, and it does not do him any good." Always have a horse's teeth looked at. Then you must try and get his inside right. If you can get bran you must do that. I know your difficulties in that direction perfectly well. But he wants something of a laxative nature to put him right inside, a bran mash, linseed oil, either in the form of oil of boiled linseed or in the form of soaked linseed or linseed cake. If you have linseed cake broken up small and mixed in the food you will introduce the oil of linseed into the animal's stomach, if it is hard and the horses don't like it, soak it and make a thick soup of it and mix with feeds, and when you have got the animal's stomach working right you can give him extra hard food, and it will do him good; otherwise it is no use cramming hard food into him. There is another thing that you can give a horse and that is Epsom salts—two or three ounces at night; then wait a night and give him another two or three ounces; then wait another night and give him a couple of ounces. That will help him a bit. There is another thing that was recommended to me some time ago, but I have never tried it because I have had plenty of other things, and that is giving a horse a boiled cabbage. I am told that it is an excellent thing, and that a horse will eat it. I was told by a friend "I always give them a boiled cabbage every Saturday night with their bran mash, and they love it, and it does them good." Some of you who have gardens might try it with hide bound animals.

Skins.

Then there is another thing that officers ought to impress on their men, and that is that they should always be looking their animal's skins over to see if they have got anything that might be ringworm or mange, and see that there are no little lumps under their throats which might mean strangles coming.

Noses.

Look at their noses to see that there are no running noses which might be catarrh which often leads to pneumonia and death. Such things as strangles and catarrh are very catching, and the moment a man sees anything that is suspicious he should report it to the N.C.O., and it is everyone's duty to isolate the animal as far as possible till the veterinary officer sees the animal. There is one point in connection with the isolating of these animals that I wish to make. They are often given their water in buckets, and you should see that the buckets of water are offered them till you are certain they have had enough; and when the buckets are taken back they should be care-

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fully cleaned and disinfected, but not at the water-trough, or otherwise they will carry strangles and catarrh half way through your units before you know where you are. I will tell you what happened to me at the beginning of the war. I had a remount depôt here for

Ropes or Chains in Mouth.

two or three months. We sent down to fetch a lot of horses from the station, and one of the men thought he had got a wild animal to deal with, and he put a rope over his tongue in a half hitch—I suppose the animal jumped about—and he jabbed him in the mouth. He never thought of loosening it again and proceeded to pull the poor brute all the way up to the remount depôt, about three-quarters of a mile, and when the animal got there his tongue was in an awful state, and it took us, in the remount depôt, where we have every facility, about three weeks to get that animal to eat his proper food. Think what would happen to one of your men on service in the field if he so injured a horse's tongue that he could not eat for two or three days! You would lose a horse simply because of bad horse management or bad horse-mastership, whichever you like to call it. Do not put ropes or chains in horses' mouths over their tongues in any shape or form whatever, because you are very apt to injure their tongues. Another

Impress on Men.

thing you should impress on your men, that they are all mounted men now, and if they lose an animal from thoughtlessness or neglect they lose half their good to their country. About three-fourths of the work of every mounted man is the care and management of his animal, because if a battery is not fit to move because the horses are wrong what is the good of a battery of artillery. It does not matter how good a Commanding Officer you have, or how good a sergeant or sergeant-major you have unless you attend to these matters. If you are going to have good horse-mastership you have got to have every individual in a unit always thinking about his animals, a man is so often on his own on fatigues &c. A man should always be thinking about his animals somewhat in this sort of way: "How am I going to get water for them? How am I going to get food for them?" He should always be thinking of how he can help them in any way he possibly can. There is one very good way in which you can help the

Keep Harness Soft.

horses, and that is keeping the harness soft. Get your men somehow or other to procure grease and rub it in the harness back and front, because soft harness will not gall a horse like hard harness. I have seen animals cut to ribbons by hard harness. Supposing you are an

On the March, Galls, &c.

officer in command of a unit with a lot of wagons or whatever they may be, when you have been going roughly half an hour on the road choose a nice convenient place by the side of the road, and draw up, and let your word of command be, "Halt, dismount"—not "Fall out" —"Look round and see that your harness is properly fitted". Now

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one of the principal causes of galls is due to tight breechings. If you put a tight loop round the animal and walk him round the barrack square it commences to rub a little hole and in time it will become a big hole. Now a breeching is properly fitted when the animal is pulling in the breast harness, the breeching should stand well away from his rump, but it should be just tight enough so that when you wish to stop the carriage going down hill he does not go back on the splinter bar. This fitting is only to be done by constant care on the part of all officers, N.C.O's. and men concerned. You have always got to be looking at it, especially the fitting of harness, when the animals are on the move. Very well, then, "Halt, dismount, look round, see that your harness is properly fitted, lift up your breast harness, lift up your breechings, tip up your saddles and let the air in, and look round for a gall starting." The moment a man sees what he thinks is a gall starting it is his duty to at once tell the N.C.O. who should at once tell the officer, and they should put their heads together to decide how they are going to stop it. You can stop it by letting out the harness, taking it up, numnah, sheepskin pads &c., or at any rate getting the friction from where the place is. The good old batteries that went abroad at the begining of the war could all go on the march for months at the time with hardly a gall at all, because you never saw a battery halt without everybody dismounting, running round his horses feet to see if there were any clinches up and the shoeing-smith was required, looking round the harness to see that everything was right, and that there was no gall. When this had been done each man would go up to his No. 1 and say, "All right Sergeant." With regard to the fitting of the harness, etc., that is one of the reasons why officers and N.C.O's have single riders who can go about their command. The normal position of an officer or a No .1 is in rear of his command on the off side so that he can see what is going on and see that the harness is properly fitted, and he can also see to the driving. Now there are thousands of fellows driving who never thought anything about it a few months ago, and it is up to you officers and N.C.O's to help them in every possible way. In fact Officers' Nos. 1 and 2 ought to have their eyes everywhere and see where things are going wrong and then try to put things right; but

Sitting on Animals Backs.

do it quietly and tactfully. Another thing I often see people offending in is this, that they sit on their horse's backs too long. You must all remember that you are pretty heavy fellows. Supposing you had got a live load on your back and it was getting a bit tired, and it is first on one side and then on the other, thats the way you riders get galls under your saddles, would you not like to get rid of it now and then and give yourself a shake? Of course you would. It is exactly the same thing with animals. Therefore get off your horse's backs and rest them whenever you can. Now there is a point about

Stuffy Stables.

stuffy stables. You will find always grooms who will stop up every-

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thing they can in their stables, and they do it because if they keep a horse in a stuffy stable it will make his coat lie down. But the result is that the animal will be a soft animal and will catch a cold sooner than any other horse. Billets in England and France are often bad. Whenever you go into billets or stables have every ventilator open and all the windows open that you possibly can. You do not want to have a direct draught on to an animal's flank because that is bad for him. You want to have the stables cold with plenty of fresh air and then you will have hard horses in them that do not mind being put out to-morrow night and brought in the next night. That is not a good thing to do but it might be unavoidable. Give them as much fresh air as you possibly can and keep your stables cold.

BRANDING.

Now, with regard to the question of branding. The only brand that is allowed on horses is the broad arrow brand, four inches to the right and four inches below the near hip. If there is a brand somewhere near that of course you would not go and put another one on. But all horses ought to have that on the near side very visible. Horses ought to be branded for the battery or unit number on the fore feet. The near hind is supposed to be really kept for the veterinary people. All Home Service horses were marked on the near hind foot and they were supposed to have a register in the veterinary hospital so that whenever they went back to the hospital they were identified, and if they went back too often they were put out of the Service. The hind feet should be left unbranded.

CLIPPING.

Now as to clipping you all know about the order as to the hair rug being left on horses, the idea is that horses should go overseas with a natural blanket on them and that it should not be too small. A new instruction has come out about clipping and that is that clipping of 3 inches on the tail need not apply in the case of officers' horses. The reason of that Order as to clipping the horse's tail is to prevent lice laying eggs there, and officers are supposed to have good grooms. With regard to the clipping of horses legs, the order is that the hair shall be left on the legs from the elbow and the stifle downwards. "Heels may be neatly trimmed with scissors." If you go and trim them up the back with clippers and trim them round the corn the mud just runs down the leg and into the fetlock, and it gets nasty and wet, you will get a cracked heel. If you leave, as you ought to leave, several inches of hair round about the corn, and do not clip it up above that, the water and mud runs down off the corn and so on to the ground, and does not come into the heel. It does not look pretty perhaps, but all horses should have that little tuft of hair left round the corn as a sort of duct to take the water off on to the ground and not into the heel.

SHOEING.

Now with regard to shoeing and shoeing smiths. Naturally we have in the Army some good shoeing smiths and we have some bad ones. We have lots of men who say that they have had a life ap-

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prenticeship, and I am always suspicious of those men because those men have been brought up in their father's forge and there has been their grandfather before them; but they merely know what they have been told by them. These bad shoers say to themselves, "I like a horse with a little foot; he is more active—nippier." Therefore they get rather too small a shoe for him, and they rasp the foot down till it fits the shoe. Then they say, "I do not like the look of this foot and I will polish it up," and they do that from the toe to the coronet. What have they done? A horse's foot is a very porous thing. It is full of little holes and if you rasp it down so as to fit the shoe and then polish it up you open the pores and let in the air and you let in the wet, and in the course of a few shoeings the farrier will come to you and say "We cannot keep a shoe on No. 4." You will ask, "Why?" He will say, "She has got such a brittle foot." I asked a Farrier the other day—"How is that?" He replied "I do not know, Sir; I suppose it is constitutional" I said, "No, it is not constitutional, do not you see that you have allowed your shoeing-smith to rasp it down to fit that shoe, and polish the hoof up to the coronet. You can see the marks of the rasp". He said, "Yes, Sir." Had he known what he was doing he would not have done it because now he has got to shoe that horse about once a fortnight whereas if he had left him with a good foot it would have lasted about a month. All the military horses before the war had beautiful feet because no rasping down like that was allowed. It is necessary to keep horses toes short, but they should not be shortened from the front, but from underneath. It is a little more trouble perhaps. I know perfectly well you get a lot of these horses from America with great big feet, and you have to get them right, but you cannot do it in one shoeing. There is an Order just out that you should draw shoes tapped for frost cogs during the winter. Then there is a new Order about bedding, which increases the allowance of bedding and increases the allowance of sawdust from 5 lbs. per horse per diem to 8 lbs. That is a much better allowance. One wants of course to always give a horse a soft bed if possible to induce him to lie down and rest his legs.

Driving.

There is just one thing I want to tell you about driving. I naturally see a lot of bad driving. I see a team coming down a hill with six horses, the wheel driver sitting back and doing all he can to keep the carriage back, and I see some of the lead and centre pulling. If you see them going up-hill you will see the wheel-driver again perhaps urging his horses to go up-hill and see some of the lead and centre taking it quietly. The golden rule is this: The wheel horses do the whole of the work down-hill; the lead and centre should be just thrown out of draught, not with their traces down to the fetlock, as one so often sees them, but just eased. The moment you begin to go up-hill the lead and centre horses should do most of the work. If you will only do it in that way you will divide your work equally between your lead and centre and wheel and you will not have, as you will always see in bad driving, teams, the wheel horses looking com-

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paratively thin and the lead and centre horses looking comparatively fat. Why cannot you pull going up-hill? Very often for this reason, that you will allow your leading horses to get too near the thing in front of you. The Order is "From the noses of the lead horses to the tail of the thing in front of them, 4 yards". How often do you have it 4 inches? Then the horses cannot pull. When you are in single units there is no reason why you should not take 40 yards and let all your horses pull. It is a very good thing in dusty weather because you will keep the dust out of the men's throats and out of the horses' throats too.

Now whether you have got a horse sick, whether you have got a horse lame or whether you have got anything the matter with him, if he has got a heavy load to pull or carry, and if you want to help him, just say to yourself, "Now how should I, if I was the animal, like to be treated under these circumstances." You may depend upon it, on the way you decide you would like to be treated yourself, you would not go very far wrong in treating the animal that way.

NOTES, HOW NOT TO DO IT.

I have made one or two notes of instances that I have seen where I am sure you would not like to be treated in that way yourself, and many of them round about Woolwich. First of all, not very long ago, I saw some horses standing on the Common and they were on fatigues. They were taking some stuff that had been dug up and put in the cart half a mile away or so, and shooting it and coming back. They were standing. Naturally they got a bit warm when taking this stuff away, and it was a biting wind, and they had no rugs on. It is in those circumstances that chills come along. The officer who was in command of the battery or his Sergt.-Major might have thought of rugs being sent out on a job like that. I saw some men coming down Shooter's Hill not very long ago, and they were on a manure fatigue. It was a very wet and foggy morning. They had their horse's rugs with them but they had them on their knees when sitting on their boxes. There was nothing wrong in that; but those rugs were turned inside out and were being wetted, so that when they came to be put on the horse's backs they were damp to the horses. You would not like to have rugs on you that were so wetted. I saw some horses being clipped and the man who was clipping them wanted one of them to stand up. The man who had got hold of the twitch proceeded to pull the horse by the twitch, the twitch is often used unnecessarily. Would you like that? I know of a case of some horses sent on fatigue at early morning stables. The driver asked if he should water them. "No," said the Sgt.-Major "you will not be long." The result was that the horses waited at the field stores and were not back until one o'clock, and neither of them had a drop of water or food. I should not care to have that sort of man for a Sgt.-Major. I saw some young officers the other day in charge of a battery. They dismounted the battery and they were all sitting on their horses themselves. Was that a good example? Get into the habit of getting off your horses whenever you can. I saw some young officers the other day coming down Shooter's Hill, and some of the lead and centre horses were

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pulling and a young fellow I noticed never looked at his horses, but had his eye fixed on something or other down the road. That does not help horses. I saw some fellows going round a corner the other day and the moment they went round the corner at a fair trot the fellow leading trotted away and he never checked his pace, and the others began to canter in the rear, the consequence being that they strung out. What happened? They pulled up one on the other like a lot of cattle trucks and got treads. That man was a bad leader. When you go round a corner you must check the pace and keep looking back to see what is going on behind you. Good driving helps animals tremendously, but bad driving is very hard on the animals indeed. There is nothing worse for them than bad driving, though of course we cannot help it sometimes. If you will only remember that horse-mastership is nothing but common-sense and forethought you will do well. Think a bit ahead and think how it is going to affect your animals if you do certain things with them, and think how you can help them in every way. I have often been asked the question about watering horses when they are hot, and my answer to that question is that when horses are hot, if you are going to groom them in the stable at once it does not matter letting them have plenty of water; but if you are going to hang them up for half an hour do not let them have too much. In other words use your own discretion, and do not do what I saw people do the other day: they had their horses out at riding drill, and brought them in in a muck sweat and watered them, hung them up to dry and one of them had colic and not to be wondered at.

SERGEANT STONEHAM, R.H.A.: About what length should the hair be on the heels?

COLONEL PRATT: I should say about two to three inches, just enough to make a sort of duct to take the water off, so that the water will fall outside the heel.

THE CHAIRMAN: I am sure that we have heard a very excellent lecture. I do hope that you will bear in mind what Colonel Pratt has told you and try and apply it. Whenever you are in any doubt about anything, just try to remember, and if you cannot remember ask your brother officers and N.C.O's, and try and not only carry out all the instructions yourselves, but see that all the men under you understand the general trend of good horse management. I am sure you will all join with me in thanking Colonel Pratt very heartily for the excellent lecture he has given us.

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THE TILT OF PIVOT.

By 2nd Lieut. A. Hutchison, R.G.A. (T).

WITH Coast Defence guns fitted with Autosights and Elevation Indicators, it is necessary to determine how much (if any) the pivot is tilted, and in what training the maximum tilt occurs. This is necessary for the following reasons:—

(1) We may wish to relevel the mounting.

(2) When the mounting is not relevelled, we have to calculate the corrections required to counteract the errors caused in the use of the Autosight or the Elevation Indicator.

(3) We may wish to fit and adjust the "Correctional gear" which eliminates errors caused in the use of the Autosight, without the mounting being relevelled.

The object of the present note is to submit simple formulæ for determining the maximum tilt and its training which may be of use, especially when the arc of traverse is very limited.

I. General Formula for the Training of Maximum Tilt.

(a). In the diagram AO represents the initial training of the gun. Place the clinometer on the gun and bring the bubble central. Note the reading d_0.

(b). Traverse the gun to some other training CO. Bring the bubble central, and note the reading d_1.

(c). Traverse the gun to a second training DO. Bring the bubble central. Note the reading d_2.

Let BO be training of maximum tilt (muzzle up), and let maximum tilt be a.

$$\text{Let } A\hat{O}B = \theta$$

$$A\hat{O}C = \phi$$

$$A\hat{O}D = \chi$$

Let all angles be measured from the initial position AO, and be reckoned positive if measured clockwise from AO, and negative if measured in the opposite direction. Also consider readings of the clinometer as positive if on the black, and negative if on the red.

Now, as shown in G.A.T. Vol. I, the tilt at any training is equal

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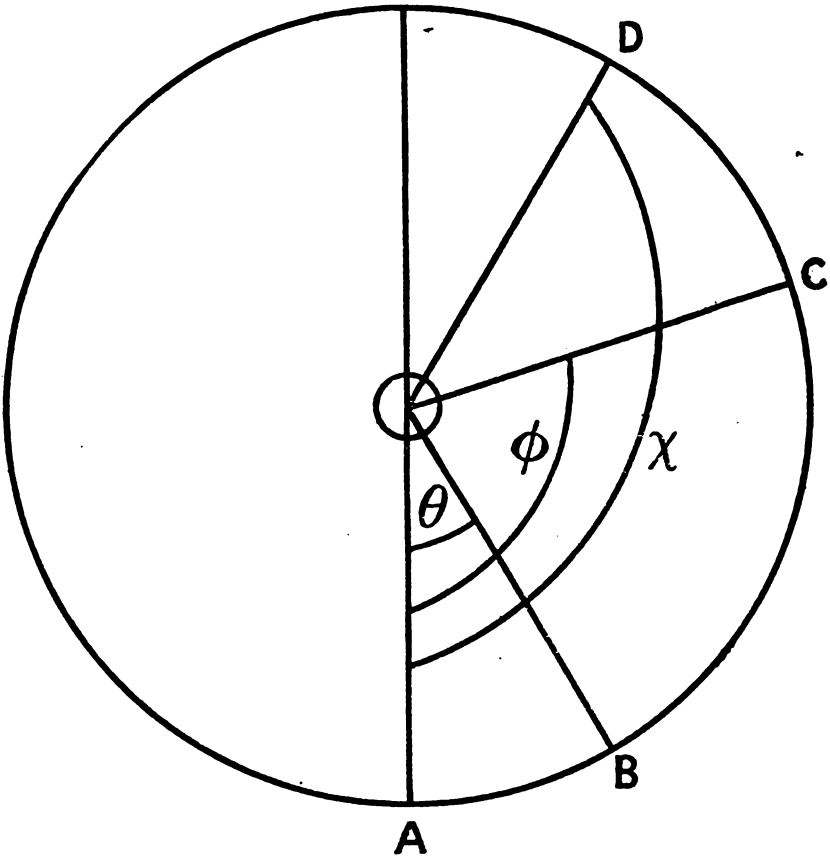

to the maximum tilt multiplied by the cosine of the angle which the training makes with the line of maximum tilt.

$\therefore$ Tilt at position AO $= a \cos \theta$

" " CO $= a \cos (\phi - \theta)$

" " DO $= a \cos (\chi - \theta)$

$\therefore$ Difference of tilts between positions CO and AO

$= a \cos (\phi - \theta) - a \cos \theta$. This is obviously equal to the difference of the clinometer readings at these positions, since the gun is traversed only.

$\therefore$ $a \cos (\phi - \theta) - a \cos \theta = d_1 - d_0 = x$ .....(a)

Similarly $a \cos (\chi - \theta) - a \cos \theta = d_2 - d_0 = y$ .....(b)

Eliminating a from these equations, we get:—

$$\frac{x}{y} = \frac{\cos (\phi - \theta) - \cos \theta}{\cos (\chi - \theta) - \cos \theta}$$

By Elementary Trigonometry, this equation is easily reduced so

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as to express θ explicitly in terms of ϕ, χ, x and y. We get thus :—

$$\tan\theta = \frac{2\left\{x \sin^2 \chi/2 - y \sin^2 \phi/2\right\}}{x \sin\chi - y \sin\phi} \quad \text{.....(c)}$$

This equation is of theoretical interest as showing that the position of maximum tilt with reference to the initial position AO, can be determined in terms of x, y, ϕ, and χ.

II. The above equation (c) becomes very simple in certain particular cases.

(a) If $\phi = 90°$, $\chi = -90°$, $\tan\theta = \dfrac{y-x}{y+x}$ .....(d)

(b) If $\phi = 90°$, $\chi = 180°$, $\tan\theta = \dfrac{y-2x}{y}$ .....(e)

(c) If $\phi = 60°$, $\chi = -60°$, $\tan\theta = \dfrac{y-x}{\sqrt{3}(y+x)}$

$$= \frac{6}{10} \times \frac{y-x}{y+x} \quad \text{.....(f)}$$

approx.

(d) If $\phi = 45°$, $\chi = -45°$, $\tan\theta = \left(\dfrac{y-x}{y+x}\right)\left(\sqrt{2}-1\right)$

$$= \frac{4}{10} \times \frac{y-x}{y+x} \quad \text{.....(g)}$$

approx.

These approximate formulæ (f) and (g) are quite accurate for practical purposes.

Equation (d) determines θ i.e. the training of maximum tilt with reference to the initial position AO, using a traverse of 180°, 90° to either side of AO.

Equation (e) determines θ, using a continuous traverse of 180° from AO, in the clockwise direction.

Equation (f) is the appropriate form, for a traverse of 120°, 60° to either side of AO.

Equation (g) is appropriate where we take a traverse of 90°, 45° to either side of AO.

A traverse of 90° is likely to be about the minimum traverse of any Coast Defence gun.

III. Amount of Tilt (Maximum).

Either of the equations (a) or (b) above, can be used to determine α, the value of maximum tilt, once we know the value of θ.

$$\text{Thus } \alpha = \frac{x}{\cos(\phi-\theta) - \cos\theta} = \frac{y}{\cos(\chi-\theta) - \cos\theta} \quad \text{.(h)}$$

knowing x, ϕ, θ or y, χ, θ

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It is interesting to note, however, the following simple forms for α, the maximum tilt.

$$\text{We have } \frac{x}{a} = \cos(\phi - \theta) - \cos\theta$$

$$\frac{y}{a} = \cos(\chi - \theta) - \cos\theta$$

(a) Put $\phi = 90^\circ$, $\chi = -90^\circ$ in these equations, and eliminating θ we get:—

$$\alpha = \sqrt{\frac{x^2 + y^2}{2}} \qquad \text{.....(i)}$$

(b) Similarly, putting $\phi = 90^\circ$, $\chi = 180^\circ$, we get:—

$$\alpha = \sqrt{x^2 - xy + \frac{y^2}{2}} \qquad \text{.....(j)}$$

(c) Similarly putting $\phi = 60^\circ$, $\chi = -60^\circ$, we get:—

$$\alpha = \frac{2}{3}\sqrt{3x^2 + 3xy + 3y^2} \qquad \text{.....(k)}$$

IV. Examples.

The following set of readings obtained casually (but carefully) from a gun will furnish data for examples of the use of the preceding formulæ.

In this case the clinometer was set at zero to begin with, and the bubble brought central. The gun was traversed from 300° to 210°, halting every 30° as in the usual method of determination. Readings on the red are reckoned negative.

Table of Readings.

TRAINING DEGREES:—	300	330	0	30	60	90	120	150	180	210
READINGS ON CLINOMETER } MINS:	0	−·4	−·3	+·2	+1	+1·6	+3·0	+3·5	+3·4	+2·9

(1) Consider initial line 30°.

$$\text{For } \phi = 90^\circ, \quad x = 3 - \cdot 2 = 2\cdot 8$$
$$\chi = -90^\circ, \quad y = 0 - \cdot 2 = -\cdot 2$$

$$\therefore \quad \tan\theta = \frac{y - x}{y + x} = \frac{-3}{2\cdot 6} = -1\cdot 16$$

$$\therefore \theta = 131^\circ \text{ or } 311^\circ.$$

∴ Training of maximum tilt is $131^\circ + 30^\circ$ i.e. 161° or 341°.

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$$\text{Also } a = \sqrt{\frac{x^2+y^2}{2}} = \sqrt{\frac{2{\cdot}8^2+{\cdot}2^2}{2}} = \sqrt{3{\cdot}94} = 1{\cdot}98 = 2 \text{ say.}$$

Maximum tilt is 2′.

(2) Consider Initial line 300°.

$$\text{For } \phi = 90^\circ, \quad x = {\cdot}2 - 0 = {\cdot}2$$
$$\chi = 180^\circ, \quad y = 3 - 0 = 3$$
$$\therefore \quad \tan\theta = \frac{y-2x}{y} = \frac{3-{\cdot}4}{3} = \frac{2{\cdot}6}{3} = {\cdot}87$$
$$\theta = 41^\circ \text{ or } 221^\circ$$

$\because$ Training of maximum tilt is $41^\circ + 300^\circ$ i.e. 341° or 161°

$$\text{Also } a = \sqrt{x^2 - xy + \frac{y^2}{2}} = \sqrt{{\cdot}2^2 - {\cdot}6 + 4{\cdot}5}$$
$$= \sqrt{3{\cdot}94} = 1{\cdot}98 = 2 \text{ say.}$$

$\therefore$ Maximum tilt is 2′.

(3) Consider Initial line 120°.

$$\text{For } \phi = 60^\circ \quad x = 3{\cdot}4 - 3 = {\cdot}4$$
$$\chi = -60^\circ, \quad y = 1 - 3 = -2$$
$$\therefore \tan\theta = \frac{6}{10} \times \frac{y-x}{y+x} = \frac{6}{10} \times \frac{-2{\cdot}4}{-1{\cdot}6} = {\cdot}9$$
$$\therefore \theta = 42^\circ \text{ or } 222^\circ$$

$\therefore$ Training of maximum tilt is $42^\circ + 120^\circ$ i.e. 162° or 342°.

$$\text{Also } a = \frac{2}{3}\sqrt{3\,(x^2 + xy + y^2} = \frac{2}{3}\sqrt{3\,({\cdot}16 - {\cdot}8 + 4)}$$
$$= \frac{2}{3}\sqrt{3 \times 3{\cdot}36} = 2{\cdot}1 \text{ approx.} = 2 \text{ say.}$$

Maximum tilt is 2′.

A reliable determination can of course only be obtained by taking the mean of several results. The above formulæ would be of value where we have a limited traverse, but in any case, they will determine the maximum tilt and its training from three readings of the clinometer viz: at AO, CO, and DO, knowing the angles ϕ and χ. In the particular cases mentioned above, they are very simple.

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CORRECTION TO ELEVATION REQUIRED, to allow for the Angle of Sight when firing up or down hill.

By Major J. Maitland-Addison, *pac.*, R.A.

THERE are certain anomalies in connection with artillery shooting on the inclined plane, which are not, in general, known to all artillery officers. Question have arisen from time to time on the correction to be applied to the elevation of a gun, as given in the range table, to allow for the angle of sight when shooting over hilly country, particularly when this angle is large. It is hoped therefore that the explanation herein given on a subject by no means new, may help to dispose of difficulties that may have been experienced in shooting, when the conditions are such as to render the correction required, one of importance.

Artillery fire at land targets may be divided into two categories, viz:—

A. Curved fire at large angles of elevation, the laying being effected by giving Quadrant Elevation to the piece by means of a clinometer, as in howitzer fire.

B. Direct fire at small angles of elevation, the laying being effected visually with Tangent Elevation, or as above, by employing Quadrant Elevation, as in the case of guns.

In either method, of laying, a correction to the elevation to allow for the angle of sight has to be applied from a theoretical point of view, but whereas the correction is of practical importance in the case of howitzers laid by Q.E., it is, on the other hand, almost negligible for the gun on account of its comparatively flat trajectory.

QUADRANT ELEVATION.

Assuming no 'jump', the Q.E. given to the piece and the angle of departure of the shell are coincident. Although spoken of as Q.E., it is the angle of departure that is herein discussed,—but as the correction required to allow for the angle of sight is the same whether there be any jump or not, the sense of the problem is in no way vitiated.

The angle of sight may be positive or negative according as the target is above or below the gun. When the ground is merely undulating the correction required to be given to the elevation is of no great importance, as the angle of sight is small. The correction in this case is practically equal to the angle of sight itself, and is therefore effected by adding or deducting this angle from the Q.E. for the range on the horizontal plane, as given in range tables, in order to get the correct Q.E. for the same range on the slope,—according as the angle of sight is positive or negative. This method of effecting

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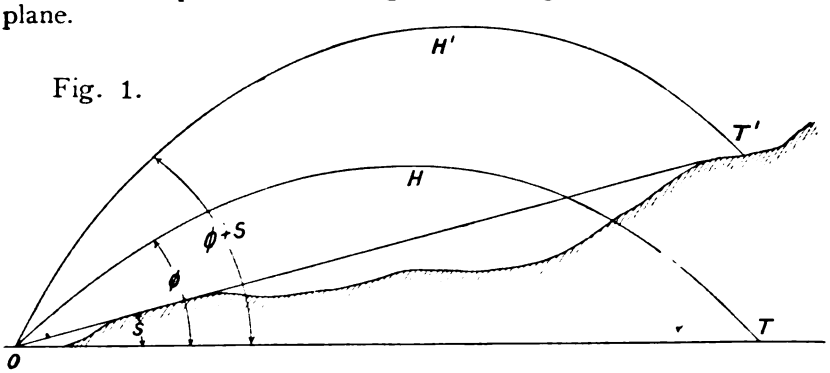
the correction arises from the principle which is popularly known as the Rigidity of the Trajectory. This principle is applicable, as is shown later, when the angles of elevation and sight are small, but not so when these angles are large. It assumes that the trajectory can be tilted up or down in the vertical plane, round the gun as a centre, without changing its shape. As an illustration, suppose a piece of stiff wire to be bent into a bow to represent the trajectory over horizontal ground as in Fig. 1, the wire being hinged at O, so as to be capable of revolving about the gun at O in the vertical plane.

Fig. 1.



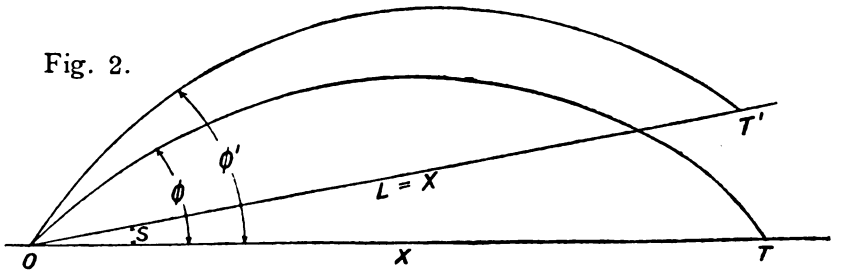
Then to obtain the range OT′ = OT, on the slope of s°, the rigid trajectory OHT represented by the stiff wire, need only be revolved into the position OH′T′, the Q.E. being changed from ϕ to $\phi + s$.

This is so near the truth when either ϕ or s are small, and particularly when both are small, that the principle of Rigidity and the resulting method of correcting the Q.E., may be accepted without argument. But when ϕ and s are large, i.e. as in howitzer fire over hilly country, the principle is no longer acceptable and the true correction must be sought.

Leaving the mathematical investigation to an appendix, the following formula gives to an excellent degree of approximation, the connection required between the Q.E. ϕ for a given range X on the horizontal, and the Q.E. ϕ' for the same range L on a slope of angle of sight s,

$$\text{Sin}\,(2\phi' \pm s) = \sin 2\,\phi.\,\cos^2 s \pm \sin s \quad \text{.....(a)}$$

Fig. 2.



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The upper signs are taken when s is positive, the lower when it is negative. In the case of howitzers which are fired at angles above 45°, which is the Q.E. for maximum range on the horizontal,

$$\sin [\pi - (2\phi' \pm s)] = \sin [\pi - 2\phi] \cos^2 s \pm \sin s \quad \text{.....(b)}$$

Formula (a), which has been derived from the mathematical consideration of the movement of a projectile in the air, is identical with that obtainable from the parabolic theory of motion "in vacuo", but is only a good approximation in the former case for limited values of s, i.e. values of s from 0° to about 10°. Its application could be extended a little further if necessary, but it is not likely that artillery will experience greater angles of sight than 10°. For example, such an angle of sight implies firing at a target 1500 feet above or below the firing point at a range of 3000 yards.

As no simple 'Gunners Rule' can be given for ascertaining the correction to be given to the elevation for firing on the slope, it has been found necessary to compile from the formula, tables of $c = \phi' - \phi$ for all values of ϕ, and of s up to 10° both positive and negative, since the correction is different in the two cases. These tables are as follows:—

Table.		
	POSITIVE ANGLE OF SIGHT.	
A_1	$\phi < 45°$	Correction c to be added.
A_2	$\phi > 45°$	Correction c to be deducted.
	NEGATIVE ANGLE OF SIGHT.	
B_1	$\phi < 45°$	Correction c to be deducted.
B_2	$\phi > 45°$	Correction c to be added.

When s is very small, we get approximately $\phi' = \phi + s$, and the correction c which has to be applied to the Q.E. ϕ, is itself equal to s. Again when ϕ is small as in Direct Fire and is comparable with s, which may be larger than ϕ, we have, to a still better degree of approximation, $\phi' = \phi + s$, which illustrate the principle of the Rigidity of the Trajectory.

But for large values of s and ϕ, the correction, as can be seen from the Tables, is greatly different from the angle of sight, and any attempt to consider the Rigidity principle as being applicable, would lead to large errors in range. Thus for $\phi = 28°$, $s = 10°$ we have $c = 15° \; 56'$ so that $\phi' = 43° \; 56'$; and for $\phi = 40°$, $s = -10°$, we have $c = 19° \; 18'$ and then $\phi' = 20° \; 42'$.

POSITIVE ANGLE OF SIGHT:—In the Appendix it is shown that the value of ϕ' for the maximum range on a slope of $s°$, is derived from the relation

$$\phi' = \frac{\pi}{4} + \frac{s}{2} \quad \text{.....(c)}$$

and the equivalent value of ϕ for the same range on the horizontal from

$$\sin 2\phi = \frac{1}{1 + \sin s} \quad \text{.....(d)}$$

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From these two formulæ, it is evident that $\phi' > 45°$, also the greater the value of s, the greater is ϕ', and the less is ϕ. Thus the maximum range on a 10° slope corresponds to $\phi' = 50°$, the equivalent ϕ being only 29° 43′ or, its complement, 60° 17′. Ranges on the horizontal corresponding to values of ϕ between the limits of 29° 43′ and 60° 17′ are therefore unobtainable on a slope of 10°.

This is illustrated in Fig. 3, which, for a certain range table for ranges up to about 10,000 yards, gives on three curves, A the elevation for the range along the horizontal, B the elevation for the same range on a slope of 10°, C the erroneous elevation assuming the principle of Rigidity of the Trajectory. The tangent to B at the point P cuts the curve A at 29° 43′ and 60° 17′, and ranges on the A curve to the right of this tangent are in excess of any represented by the B curve. This explains why Table A_1 is tailed off diagonally. The close coincidence of the B and C curves up to about 30°, shows that the asumption of the Rigidity principle leads to errors which, although appreciable from a practical point of view, are small compared with those due to higher elevations. The maximum range attainable on the slope, is 8845 yards, (as exemplified by the curve B) for $\phi' = 50°$, while ϕ for the same range on the horizontal is either 29° 43′ or 60° 17′ Assuming the Rigidity of the Trajectory would mean attempting to get this range on the slope with a Q.E. of $\phi' = 39°\ 43'$, the actual resulting range being 8,160 yards—thus involving an error of nearly 700 yards on the low side, —an error sufficiently large to lead astray any Battery Commander unless he be acquainted with the fact that the assumption is not applicable.

In the case of range tables constructed for the higher elevations above 45° i.e. from 70° to 45°, the correction for the angle of sight has to be deducted from the Q.E. for the horizontal range. From the explanation already given, it is clear that Table A_2 must commence diagonally as shown.

NEGATIVE ANGLE OF SIGHT:—When s is negative as in firing down hill the value of ϕ' for the maximum range on the incline is obtainable from

$$\phi' = \frac{\pi}{4} - \frac{s}{2} \quad \text{.....(e)}$$

and the equivalent ϕ for the same range on the horizontal from

$$\sin 2\phi = \frac{1}{1 - \sin s} \quad \text{.....(f)}$$

from which it is evident that ϕ' decreases as s increases, and is always less than 45°—further, ϕ is imaginary—in other words, a greater maximum range can be obtained down hill than is possible on the horizontal—the reverse of the case for a positive angle of sight. Putting $\phi = 45°$ in (a) for the maximum range on the horizontal and using the lower signs, the value of ϕ' for the same range on the incline is derived from

$$\sin (2\phi' + s) = \cos^2 s - \sin s \quad \text{.....(g)}$$

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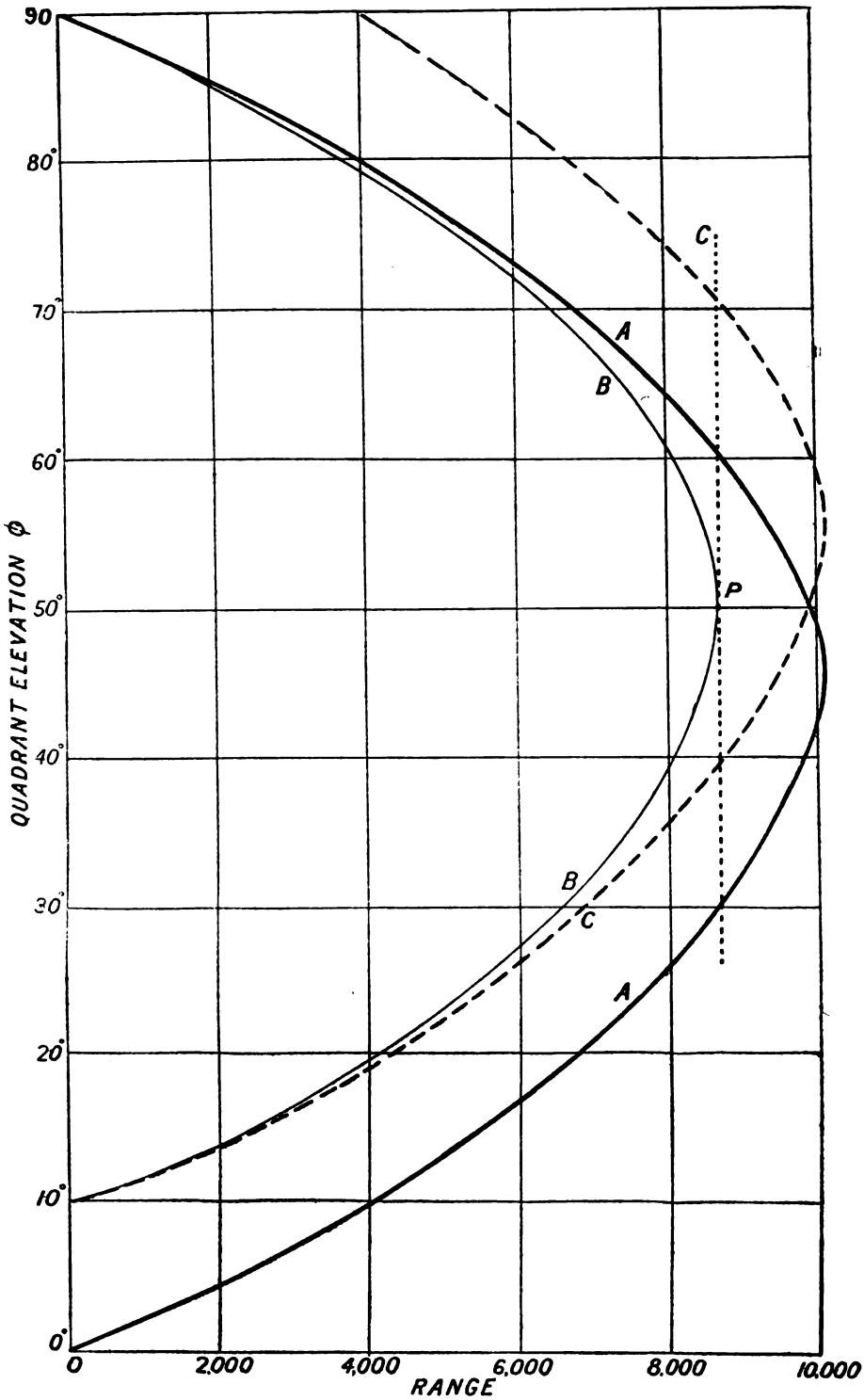

FIGURE 3. ANGLE OF SIGHT = + 10°

A = Elevation for Range on Horizontal.
B = ,, ,, same Range on Slope.
C = ,, corrected by Principle of Rigidity of Trajectory

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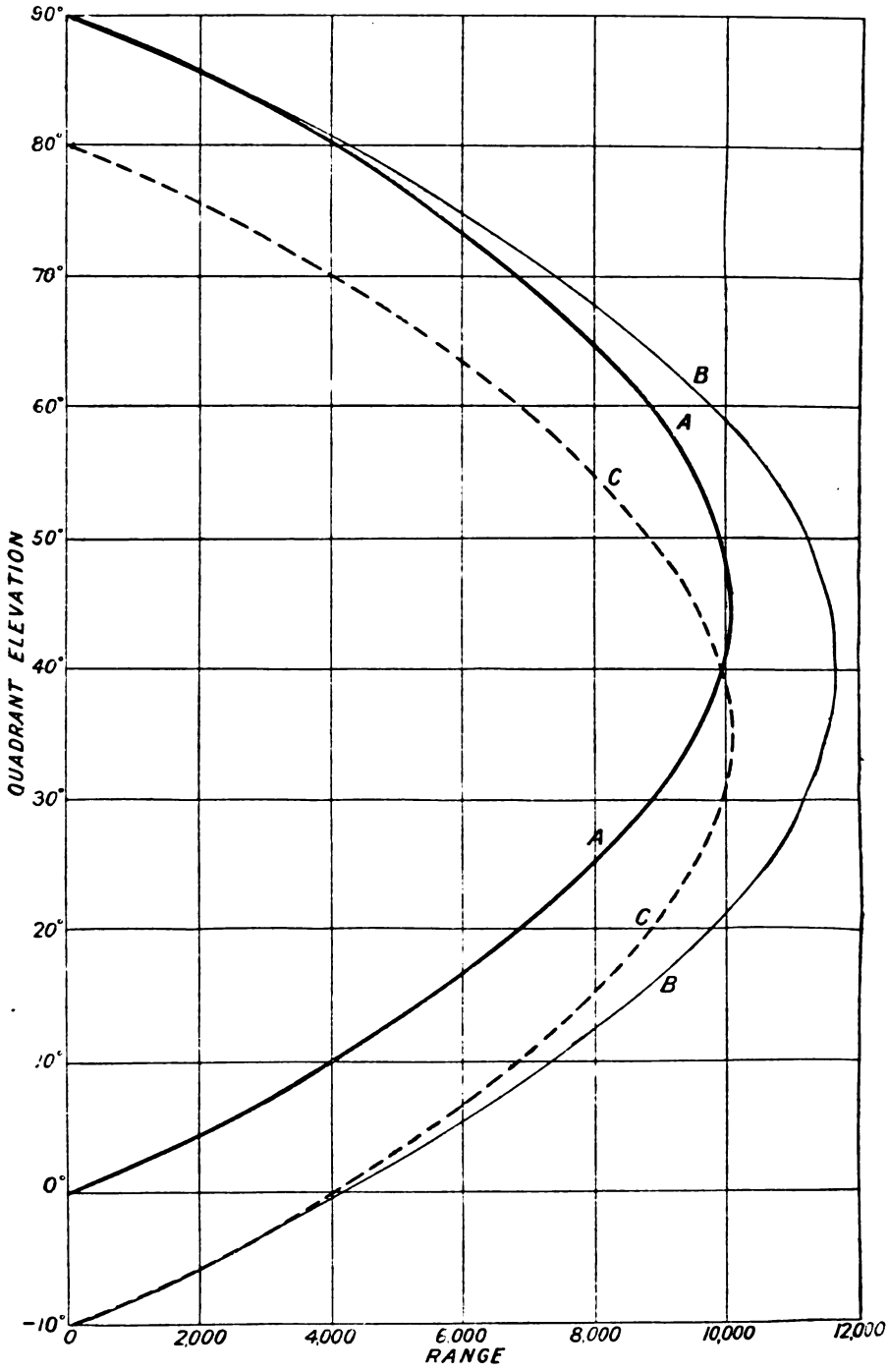

FIGURE 4. ANGLE OF SIGHT = − 10°

A = Elevation for Range on Horizontal.
B = ,, ,, same Range on Slope.
C = ,, corrected by Principle of Rigidity of Trajectory

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for any assumed value of s. Thus for $\phi = 45^\circ$, $s = 10^\circ$, the value of ϕ' is $21^\circ\ 23'$ or its complement $58^\circ\ 37'$, derived from

$$\sin\,[\pi - (2\phi' + s)] = \cos^2 s - \sin s \quad \text{.....(h)}$$

Fig. 4, similar to Fig. 3, illustrates the situation graphically for the same range table.

The maximum range on the horizontal for 45° is 10,061 yards whereas for the same range on the slope of 10°, the Q.E. is 21° 23′. The maximum range on the slope is about 11,670 yards for a Q.E. of 40°. The total increase in range is therefore about 1,600 yards or 16%, for this particular range table. It is by no means small, and it is conceivable that an occasion might arise when it would be very useful to know how much extra range could be obtained when firing down hill. This can be ascertained with very slight error by prolonging the trajectory at the point of descent on the horizontal to meet the slope, considering it to be part of a parabola as shown in appendix, so that

$$L = X\,\frac{\tan\beta + \tan s}{\tan\beta\cos s} = X\mu \quad \text{.....(i)}$$

in which X = range on the horizontal

L = range on the slope

β = angle of descent on the horizontal

s = angle of sight.

A table of μ,—Table C—has been compiled for negative values of s up to 10° and for all likely values of β, which can be ascertained from the range table so that L can be quickly determined.

Here again it is worth while to ascertain the error in range caused by applying the Rigidity of the Trajectory principle. For a range of 10,061 yards on the slope of 10°, the erroneous Q.E. due to such assumption would be 35°, as compared with the true Q.E. of 20° 23′, and the resulting range as shown by Fig. 4, curve B, would be about 11,530 yards, an error of 1464 yards excess range. This speaks for itself, and no further comment need be made on the error in range due to a wrong epplication of the Rigidity principle.

TANGENT ELEVATION.

There is little to be said as regards this method of giving elevation to a gun. When using this mode of laying, the T.E. will, in general, be so small as to come within the scope of the Rigidity principle, as can be seen in the Tables. The correction required is

$$c_1 = c - s$$

where c is given in Tables A and B. Taking as an example a large angle of T.E. viz: 15° for a gun firing up a slope of 10°, the correction required is + 36′, so that the corrected T.E. would be 15° 36′, and the error in range caused by neglecting the correction would be small.

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APPENDIX.

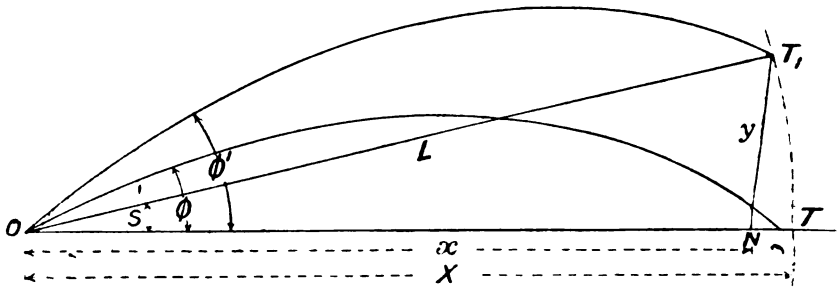

Fig. 5.

Consider two trajectories on OT and OT_1 in which the angles of departure at O are ϕ and ϕ'

M.V. in each case — $Vf.s.$ Remaining pseudo velocity at T and T_1—$u.f.s.$

Ballistic coefficient $C = \dfrac{w}{\kappa\,\sigma\,\tau\,d^2}$ in each case

Altitude factors f_x and f_x = respectively

range OT	... ...	X
range OT_1	... ...	L
range ON	... ...	x
angle of sight...	...	s

Employing Siacci's system of formulæ:—

For the trajectory OT

$$X = \frac{C.\,f_x}{\beta_x}\,(S_v - S_u) \quad \text{.....(1)}$$

$$\tan\phi = \frac{C.\,f_x}{\bar{\beta}_\phi \cos\phi}\left(I_v - \frac{A_v - A_u}{S_v - S_u}\right) \quad \text{.....(2)}$$

For the trajectory O T_1

$$x = L\cos s = \frac{C.\,f_x}{\beta_x}\,(S_v - S_u) \quad \text{.....(3)}$$

$$y/x = \tan s = \tan\phi' - \frac{C.\,f_x}{\bar{\beta}_{\phi'}\cos^2\phi'}\left(I_v - \frac{A_v - A_u}{S_v - S_u}\right) \quad \text{.....(4)}$$

in which $\bar{\beta}x$, $\bar{\beta}_\phi$, $\bar{\beta}z$, $\bar{\beta}_\phi$, are the respective integrals of Siaccis' β function, necessary to adjust the formulæ. Denoting $(S_v - S_u)$ by z and $\left(I_v - \dfrac{A_v - A_u}{S_v - S_u}\right)$ by $\dfrac{a}{2}$ and dividing (2) by (1) and (4) by (3)

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$$\frac{\sin 2\phi}{X} = \frac{\bar{\beta}_x}{\bar{\beta}_\phi}\,\frac{a}{z}$$

$$\frac{2\cos^2\phi'(\tan\phi' - \tan s)}{L\cos s} = \frac{\bar{\beta}_{\phi'}}{\bar{\beta}_x}\,\frac{z}{a}$$

where by a third division

$$\frac{2\cos^2\phi'(\tan\phi' - \tan s)}{\sin 2\phi}\;\frac{X}{L\cos s} = \frac{\bar{\beta}_x}{\bar{\beta}_{\phi'}}\,\frac{\beta_\phi}{\beta_x}$$

The coefficients $\bar{\beta}$ in this equation cannot be determined absolutely, but they vary slowly from unity, and while $\frac{\bar{\beta}_x}{\bar{\beta}_{\phi'}}$ tends to increase or decrease as the case may be, $\frac{\beta_\phi}{\beta_x}$ tends to decrease or increase, so that the product may be taken to a good degree of approximation as unity. Also when s is small, we may as an approximation put $\bar{\beta}_x = \beta_x$ secs s, so that from (1) and (3) L = X and then the above equation becomes

$$2\cos^2\phi'(\tan\phi' - \tan s) = \sin 2\phi\cos s$$

or more generally for both positive and negative values of s, also for angles of departure greater and less than 45°

$$\sin[\pi - (2\phi' \pm s)] = \sin[\pi - 2\phi]\cos^2 s \pm \sin s \quad \text{.....(5)}$$

the upper signs being taken when s is positive i.e. firing up hill, the lower when s is negative, i.e firing down hill, and π being omitted from the brackets for angles of departure less than 45°. This formula can, with good accuracy, be applied to any case where the angle of sight s does not exceed about 10°, but no great loss of accuracy would be experienced, for values of s, a little more extended. It is also suitable for application to range tables in which the elevations are from 70° down to 45°. This formula is identical with that derived from a similar consideration of the motion "in vacuo".

For positive angle of sight,

$$\begin{aligned}\sin(2\phi' - s) &= \sin 2\phi\cos^2 s + \sin s\\ &= Ca\cos^2 s + \sin s\end{aligned}$$

and a, and therefore L increases as ϕ' increases, so that the maximum range on the slope is given by putting this equation equal to unity, and then

$$\phi' = \frac{\pi}{4} + \frac{s}{2} \quad \text{.....(6)}$$

$$\sin 2\phi = \frac{1}{1 + \sin s} \quad \text{.....(7)}$$

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From these two formulæ, it is evident that the greater the value of s, the greater is ϕ' and the less is ϕ,—also $\phi' > 45°$ for the maximum value of L.

Similarly for negative angles of sight, the maximum range is obtained when

$$\phi' = \frac{\pi}{4} - \frac{s}{2} \qquad \text{.....(8)}$$

$$\sin 2\phi = \frac{1}{1 - \sin s} \qquad \text{.....(9)}$$

from which it can be seen that for the maximum range on a downward gradient, $\phi' < 45°$, also since ϕ is imaginary, longer ranges than the maximum possible on the horizontal can be obtained on the slope

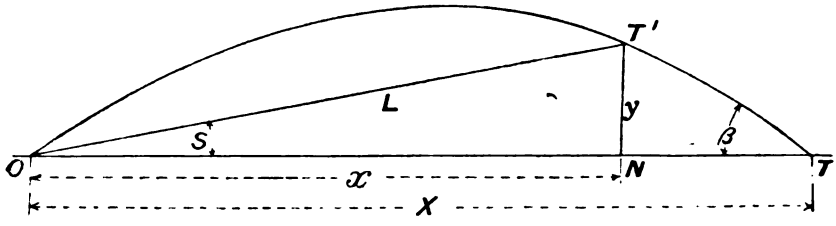

Fig. 6.

It is useful to have a relation between L and X, and s. This can be best found in terms of the angle of descent β, assuming the trajectory at T to be a parabola for all practical purposes, If t secs. be the time of flight to N, and T secs. the time to T

$$x = V_1 \cos\beta\, t = L \cos s$$

$$y = \tfrac{1}{2}\, g\, t\,(T - t) = L \sin s$$

hence eliminating t, and putting $T = \dfrac{X}{V' \cos\beta}$, also putting

$\dfrac{g}{V_1^2} = \dfrac{\sin 2\beta}{X}$, we get

$$L = X \frac{\tan\beta \pm \tan s}{\tan\beta \cos s} \qquad \text{.....(10)}$$

the fictitious velocity V_1 being eliminated, the negative sign being used for positive values of s and the positive sign for negative values of s.

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TABLE A 1. Correction Table to Quadrant Elevation for Positive Angle of Sight. $\phi < = 45^\circ$

The figures given in the body of this table are the corrections c which must be *added* to the Quadrant Elevation ϕ for a given range on the horizontal so as to obtain the Correct Quadrant Elevation ϕ' for the same range on an uphill slope of angle of sight s.

Angle of Sight.

ϕ°	0°		1°		2°		3°		4°		5°		6°		7°		8°		9°		10°	
	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′
0	0	0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0
1	0	0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0
2	0	0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0
3	0	0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0
4	0	0	1	0	2	0	3	0	4	1	5	1	6	1	7	1	8	1	9	0	10	0
5	0	0	1	1	2	1	3	1	4	1	5	1	6	1	7	1	8	1	9	1	10	0
6	0	0	1	1	2	1	3	1	4	2	5	2	6	2	7	2	8	2	9	2	10	1
7	0	0	1	1	2	2	3	2	4	3	5	3	6	3	7	4	8	4	9	3	10	2
8	0	0	1	1	2	2	3	3	4	4	5	4	6	5	7	6	8	6	9	5	10	4
9	0	0	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	8	9	7	10	7
10	0	0	1	2	2	4	3	5	4	6	5	8	6	9	7	9	8	10	9	10	10	11
11	0	0	1	2	2	4	3	6	4	8	5	10	6	11	7	12	8	13	9	13	10	14
12	0	0	1	2	2	5	3	7	4	10	5	12	6	13	7	15	8	16	9	17	10	18
13	0	0	1	3	2	6	3	9	4	12	5	14	6	16	7	18	8	20	9	21	10	23
14	0	0	1	3	2	7	3	11	4	14	5	17	6	20	7	22	8	25	9	27	10	29
15	0	0	1	4	2	9	3	13	4	17	5	20	6	24	7	27	8	30	9	33	10	36
16	0	0	1	5	2	10	3	15	4	20	5	24	6	28	7	32	8	36	9	40	10	44
17	0	0	1	6	2	12	3	17	4	23	5	28	6	33	7	38	8	43	9	48	10	52
18	0	0	1	7	2	14	3	20	4	26	5	32	6	39	7	45	8	51	9	56	11	1
19	0	0	1	8	2	16	3	23	4	30	5	38	6	46	7	52	9	0	10	6	11	12
20	0	0	1	9	2	18	3	26	4	35	5	44	6	53	8	1	9	10	10	18	11	25
21	0	0	1	10	2	20	3	30	4	40	5	50	7	0	8	10	9	20	10	30	11	38
22	0	0	1	11	2	23	3	34	4	46	5	58	7	10	8	21	9	33	10	44	11	56
23	0	0	1	13	2	26	3	39	4	53	6	6	7	20	8	34	9	48	11	2	12	14
24	0	0	1	15	2	30	3	45	5	0	6	16	7	32	8	48	10	6	11	22	12	38
25	0	0	1	17	2	34	3	52	5	10	6	29	7	47	9	7	10	28	11	51	13	13
26	0	0	1	19	2	38	3	59	5	20	6	43	8	2	9	26	10	54	12	22	13	52
27	0	0	1	21	2	43	4	7	5	31	6	59	8	20	9	52	11	38	13	4	14	52
28	0	0	1	24	2	49	4	16	5	44	7	18	8	44	10	24	12	16	14	6	15	56
29	0	0	1	27	2	56	4	28	6	1	7	40	9	16	11	10	13	20	15	20	18	28
30	0	0	1	31	3	4	4	41	6	21	8	6	9	59	12	5	14	38	—		—	
31	0	0	1	36	3	13	4	57	6	48	8	39	11	7	13	49	—		—		—	
32	0	0	1	41	3	24	5	18	7	25	9	41	12	44	—		—		—		—	
33	0	0	1	48	3	39	5	47	8	17	11	19	—		—		—		—		—	
34	0	0	1	55	4	0	6	27	9	29	—		—		—		—		—		—	
35	0	0	2	4	4	30	7	21	—		—		—		—		—		—		—	
36	0	0	2	16	5	12	—		—		—		—		—		—		—		—	
37	0	0	2	31	6	8	—		—		—		—		—		—		—		—	
38	0	0	2	55	—		—		—		—		—		—		—		—		—	
39	0	0	3	34	—		—		—		—		—		—		—		—		—	
40	0	0	—		—		—		—		—		—		—		—		—		—	

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TABLE A2. Correction Table to Quadrant Elevation for Positive Angle of Sight. $\phi > = 45^\circ$

The figures given in the body of this Table are the corrections c which must be *deducted* from the Quadrant Elevation ϕ for a given rang on the horizontal so as to obtain the Correct Quadrant Elevation ϕ' f the same range as on uphill slope of Angle of Sight S.

Angle of Sight.

ϕ°	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
45	0 0	—	—	—	—	—	—	—	—	—	—
46	0 0	—	—	—	—	—	—	—	—	—	—
47	0 0	—	—	—	—	—	—	—	—	—	—
48	0 0	—	—	—	—	—	—	—	—	—	—
49	0 0	—	—	—	—	—	—	—	—	—	—
50	0 0	—	—	—	—	—	—	—	—	—	—
51	0 0	2 34	—	—	—	—	—	—	—	—	—
52	0 0	1 55	—	—	—	—	—	—	—	—	—
53	0 0	1 31	4 8	—	—	—	—	—	—	—	—
54	0 0	1 16	3 12	—	—	—	—	—	—	—	—
55	0 0	1 64	2 30	4 21	—	—	—	—	—	—	—
56	0 0	0 55	2 0	3 27	5 29	—	—	—	—	—	—
57	0 0	0 48	1 39	2 47	4 17	6 19	—	—	—	—	—
58	0 0	0 41	1 24	2 18	3 25	4 41	6 44	—	—	—	—
59	0 0	0 30	1 13	1 57	2 48	3 39	5 7	6 49	—	—	—
60	0 0	0 31	1 4	1 41	2 21	3 6	3 59	5 5	6 38	—	—
61	0 0	0 27	0 56	1 28	2 1	2 40	3 10	4 10	5 20	6 20	8 29
62	0 0	0 24	0 40	1 16	1 44	2 18	2 44	3 24	4 16	5 6	5 56
63	0 0	0 21	0 43	1 7	1 31	1 59	2 20	2 52	3 38	4 4	4 52
64	0 0	0 19	0 38	0 59	1 20	1 43	2 2	2 26	2 54	3 22	3 52
65	0 0	0 17	0 34	0 52	1 10	1 29	1 47	2 7	2 28	2 51	3 13
66	0 0	0 15	0 30	0 45	1 0	1 16	1 32	1 48	2 6	2 22	2 38
67	0 0	0 13	0 26	0 39	0 53	1 6	1 20	1 34	1 48	2 2	2 14
68	0 0	0 11	0 23	0 34	0 46	0 58	1 10	1 21	1 33	1 44	1 56
69	0 0	0 10	0 20	0 30	0 40	0 50	1 0	1 10	1 20	1 30	1 38
70	0 0	0 9	0 18	0 26	0 35	0 44	0 53	1 1	1 10	1 18	1 25
71	0 0	0 8	0 16	0 23	0 30	0 38	0 46	0 52	1 0	1 6	1 12
72	0 0	0 7	0 14	0 20	0 26	0 38	0 39	0 45	0 51	0 56	1 1
73	0 0	0 6	0 12	0 17	0 23	0 28	0 33	0 38	0 43	0 48	0 52
74	0 0	0 5	0 10	0 15	0 20	0 24	0 28	0 32	0 36	0 40	0 42
75	0 0	0 4	0 9	0 13	0 17	0 20	0 24	0 27	0 30	0 33	0 36
76	0 0	0 3	0 7	0 11	0 14	0 17	0 20	0 22	0 25	0 27	0 29
77	0 0	0 3	0 6	0 9	0 12	0 14	0 16	0 18	0 20	0 21	0 23
78	0 0	0 2	0 5	0 7	0 10	0 12	0 13	0 15	0 16	0 17	0 18
79	0 0	0 2	0 4	0 6	0 8	0 9	0 11	0 12	0 13	0 13	0 14
80	0 0	0 2	0 4	0 5	0 6	0 8	0 9	0 9	0 10	0 10	0 11
81	0 0	0 2	0 3	0 4	0 5	0 6	0 7	0 8	0 8	0 ·7	0 7
82	0 0	0 1	0 2	0 3	0 4	0 4	0 5	0 6	0 6	0 5	0 4
83	0 0	0 1	0 2	0 2	0 3	0 3	0 3	0 4	0 4	0 3	0 2
84	0 0	0 1	0 1	0 1	0 2	0 2	0 2	0 2	0 2	0 2	0 1
85	0 0	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 1	0 0
86	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
87	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
88	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
89	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
90	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

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TABLE B1. Correction Table to Quadrant Elevation for Negative Angle of Sight. $\phi < = 45°$

The figures given in the body of this Table are the corrections c which must be *deducted* from the Quadrant Elevation ϕ for a given range on the horizontal to obtain the Correct Quadrant Elevation ϕ' for the same range on a downhill slope of Angle of Sight S.

Angle of Sight.

$\phi°$	0°		1°		2°		3°		4°		5°		6°		7°		8°		9°		10°	
	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′	°	′
0	0	0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0
1	0	0	1	0	2	0	3	0	4	0	5	0	6	1	7	1	8	1	9	1	10	1
2	0	0	1	0	2	0	3	0	4	1	5	1	6	1	7	2	8	2	9	3	10	3
3	0	0	1	0	2	0	3	1	4	1	5	2	6	2	7	3	8	3	9	4	10	5
4	0	0	1	0	2	1	3	2	4	2	5	3	6	3	7	4	8	5	9	6	10	7
5	0	0	1	1	2	1	3	2	4	3	5	4	6	5	7	6	8	7	9	8	10	9
6	0	0	1	1	2	2	3	3	4	4	5	5	6	7	7	8	8	9	9	10	10	12
7	0	0	1	1	2	2	3	3	4	5	5	6	6	8	7	10	8	11	9	13	10	15
8	0	0	1	1	2	2	3	4	4	6	5	8	6	10	7	12	8	14	9	16	10	18
9	0	0	1	2	2	3	3	5	4	7	5	9	6	12	7	14	8	17	9	19	10	22
10	0	0	1	2	2	4	3	6	4	9	5	11	6	14	7	17	8	20	9	23	10	27
11	0	0	1	2	2	5	3	7	4	10	5	13	6	16	7	20	8	24	9	20	10	32
12	0	0	1	3	2	6	3	8	4	12	5	15	6	19	7	23	8	27	9	32	10	37
13	0	0	1	3	2	7	3	10	4	14	5	18	6	22	7	27	8	32	9	37	10	43
14	0	0	1	4	2	8	3	12	4	16	5	21	6	26	7	32	8	37	9	43	10	49
15	0	0	1	4	2	9	3	14	4	19	5	24	6	30	7	37	8	43	9	49	10	56
16	0	0	1	5	2	11	3	16	4	22	5	28	6	35	7	42	8	49	9	56	11	3
17	0	0	1	6	2	12	3	18	4	25	5	32	6	40	7	48	8	55	10	3	11	11
18	0	0	1	7	2	14	3	21	4	28	5	36	6	45	7	54	9	2	10	11	11	20
19	0	0	1	8	2	16	3	24	4	32	5	41	6	51	8	0	9	9	10	19	11	29
20	0	0	1	9	2	18	3	27	4	37	5	47	6	57	8	7	9	17	10	28	11	39
21	0	0	1	10	2	21	3	31	4	42	5	52	7	3	8	15	9	26	10	37	11	49
22	0	0	1	12	2	24	3	35	4	47	5	58	7	10	8	23	9	36	10	48	12	0
23	0	0	1	13	2	27	3	40	4	53	6	5	7	18	8	32	9	46	10	59	12	12
24	0	0	1	15	2	30	3	45	4	59	6	13	7	27	8	42	9	56	11	11	12	25
25	0	0	1	17	2	33	3	49	5	5	6	21	7	37	8	53	10	8	11	24	12	39
26	0	0	1	19	2	36	3	54	5	12	6	30	7	47	8	4	10	21	11	47	12	54
27	0	0	1	21	2	40	4	0	5	20	6	39	7	58	9	16	10	34	11	58	13	10
28	0	0	1	23	2	45	4	7	5	29	6	50	8	10	9	30	10	49	12	8	13	26
29	0	0	1	26	2	51	4	14	5	38	7	1	8	24	9	45	11	5	12	25	13	44
30	0	0	1	29	2	57	4	22	5	47	7	12	8	37	10	0	11	22	12	44	14	6
31	0	0	1	32	3	1	4	30	5	38	7	26	8	52	10	17	11	41	13	4	14	27
32	0	0	1	36	3	8	4	39	6	10	7	42	9	13	10	43	12	1	13	27	14	51
33	0	0	1	41	3	17	4	53	6	27	8	0	9	28	10	56	12	24	13	52	15	17
34	0	0	1	46	3	28	5	8	6	44	8	18	9	50	11	21	12	49	14	17	15	44
35	0	0	1	53	3	40	5	23	7	2	8	32	10	12	11	45	13	15	14	45	16	14
36	0	0	2	0	3	54	5	42	7	24	9	4	10	38	12	12	13	43	15	12	16	45
37	0	0	2	8	4	10	6	2	7	47	9	28	11	7	12	42	14	14	15	38	17	17
38	0	0	2	18	4	28	6	24	8	13	9	54	11	38	13	15	14	49	16	20	17	52
39	0	0	2	31	4	49	6	48	8	42	10	25	12	12	13	51	15	26	17	0	18	32
40	0	0	2	45	5	13	7	17	9	14	11	2	12	48	14	29	16	7	17	43	19	18
41	0	0	3	5	5	34	7	50	9	54	11	34	13	28	13	12	16	52	18	31	20	4
42	0	0	3	31	6	18	8	28	10	37	12	27	14	14	15	59	17	40	19	8	20	54
43	0	0	4	4	7	0	9	14	11	23	13	16	15	3	16	49	18	20	20	0	21	44
44	0	0	4	45	7	48	10	6	12	13	14	8	15	56	17	42	19	22	21	4	22	38
45	0	0	5	38	8	43	11	3	13	8	13	4	10	54	18	38	20	21	22	0	23	37

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TABLE B2. Correction Table to Quadrant Elevation for Negative Angle of Sight. $\phi > = 45°$

The figures given in the body of this Table are the corrections which must be *added* to the Quadrant Elevation ϕ for a given range on the horizontal to obtain the Correct Quadrant Elevation ϕ' for the same range on a downhill slope of Angle of Sight S.

Angle of Sight.

$\phi°$	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
45	0 0	4 38	6 43	8 3	9 8	10 4	10 54	11 38	12 21	13 0	13 37
46	0 0	3 45	5 48	7 6	8 13	9 8	9 50	10 42	11 22	12 4	12 38
47	0 0	3 4	5 0	6 14	7 23	8 16	9 3	9 49	10 30	11 0	11 44
48	0 0	2 31	4 18	5 29	6 37	7 27	8 14	8 59	9 40	10 8	10 54
49	0 0	2 5	3 43	4 50	5 54	6 42	7 28	8 12	8 52	9 31	10 4
50	0 0	1 45	3 13	4 17	5 14	6 2	6 48	7 29	8 7	8 43	9 18
51	0 0	1 31	2 49	3 48	4 42	5 25	6 12	6 51	7 25	8 0	8 32
52	0 0	1 18	2 28	3 24	4 13	4 54	5 38	6 15	6 49	7 20	7 52
53	0 0	1 8	2 10	3 2	3 47	4 28	5 7	5 42	6 14	6 38	7 17
54	0 0	1 0	1 54	2 42	3 24	4 2	4 38	5 12	5 43	6 12	6 45
55	0 0	0 53	1 40	2 23	3 2	3 38	4 12	4 45	5 15	5 45	6 14
56	0 0	0 46	1 28	2 8	2 44	3 18	3 50	4 21	4 49	5 17	5 44
57	0 0	0 41	1 17	1 53	2 27	3 0	3 28	3 56	4 24	4 52	5 17
58	0 0	0 36	1 8	1 39	2 10	2 42	3 13	3 43	4 1	4 27	4 15
59	0 0	0 32	1 1	1 30	1 58	2 26	2 52	3 17	3 4	4 4	4 27
60	0 0	0 29	0 57	1 22	1 47	2 12	2 37	3 0	3 22	3 44	4 6
61	0 0	0 26	0 51	1 14	1 38	2 1	2 24	2 45	3 5	3 25	3 44
62	0 0	0 23	0 45	1 7	1 29	1 50	2 10	2 30	2 49	3 8	3 26
63	0 0	0 21	0 40	1 0	1 20	1 39	1 58	2 16	2 34	2 52	3 10
64	0 0	0 19	0 36	0 54	1 12	1 30	1 47	2 4	2 21	2 37	2 54
65	0 0	0 17	0 33	0 49	1 5	1 21	1 37	1 53	2 8	2 24	2 39
66	0 0	0 15	0 30	0 45	0 59	1 13	1 27	1 42	1 56	2 11	2 25
67	0 0	0 13	0 27	0 40	0 53	1 5	1 18	1 32	1 40	1 59	2 12
68	0 0	0 12	0 24	0 35	0 47	0 58	1 10	1 23	1 36	1 48	2 0
69	0 0	0 10	0 21	0 31	0 42	0 52	1 3	1 15	1 26	1 37	1 49
70	0 0	0 9	0 18	0 27	0 37	0 47	0 57	1 7	1 17	1 28	1 39
71	0 0	0 8	0 16	0 24	0 32	0 41	0 51	1 0	1 9	1 19	1 29
72	0 0	0 7	0 14	0 21	0 28	0 36	0 45	0 54	1 2	1 11	1 20
73	0 0	0 6	0 12	0 18	0 25	0 32	0 40	0 48	0 55	1 3	1 11
74	0 0	0 5	0 11	0 16	0 22	0 28	0 35	0 42	0 49	0 56	1 3
75	0 0	0 4	0 9	0 14	0 19	0 24	0 30	0 37	0 43	0 49	0 56
76	0 0	0 4	0 8	0 12	0 16	0 21	0 26	0 32	0 37	0 43	0 49
77	0 0	0 3	0 7	0 10	0 14	0 18	0 22	0 27	0 32	0 37	0 43
78	0 0	0 3	0 6	0 8	0 12	0 15	0 19	0 23	0 27	0 32	0 37
79	0 0	0 2	0 5	0 7	0 10	0 13	0 18	0 20	0 24	0 28	0 32
80	0 0	0 2	0 4	0 6	0 9	0 11	0 14	0 17	0 20	0 23	0 27
81	0 0	0 2	0 3	0 5	0 7	0 9	0 12	0 14	0 17	0 19	0 22
82	0 0	0 1	0 2	0 4	0 6	0 8	0 10	0 12	0 14	0 16	0 18
83	0 0	0 1	0 2	0 3	0 5	0 6	0 8	0 10	0 11	0 13	0 15
84	0 0	0 1	0 2	0 3	0 4	0 5	0 7	0 8	0 9	0 10	0 12
85	0 0	0 1	0 1	0 2	0 3	0 4	0 5	0 6	0 7	0 8	0 9
86	0 0	0 0	0 1	0 2	0 2	0 3	0 3	0 4	0 5	0 6	0 7
87	0 0	0 0	0 0	0 1	0 1	0 2	0 2	0 3	0 3	0 4	0 5
88	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
89	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0
90	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0	0 0

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TABLE C.

Table of μ.

Angle of descent β as given in Range Table.
Angles of Sight 1° to 10°.

β°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°
20	1·047	1·095	1·144	1·193	1·243	1·294	1·346	1·399	1·452	1·506
22	1·043	1·086	1·130	1·175	1·222	1·269	1·316	1·363	1·411	1·159
24	1·039	1·078	1·118	1·160	1·203	1·245	1·288	1·331	1·375	1·418
26	1·036	1·071	1·108	1·146	1·185	1·223	1·263	1·303	1·343	1·383
28	1·033	1·065	1·099	1·134	1·169	1·204	1·241	1·278	1·316	1·353
30	1·031	1·060	1·092	1·103	1·155	1·188	1·222	1·256	1·291	1·326
32	1·029	1·056	1·085	1·114	1·143	1·174	1·205	1·237	1·269	1·301
34	1·027	1·052	1·076	1·105	1·133	1·162	1·190	1·220	1·250	1·279
36	1·025	1·048	1·072	1·098	1·124	1·151	1·178	1·205	1·233	1·261
38	1·023	1·045	1·068	1·091	1·116	1·141	1·166	1·192	1·218	1·244
40	1·022	1·043	1·046	1·085	1·108	1·132	1·155	1·180	1·204	1·229
42	1·020	1·040	1·060	1·080	1·101	1·123	1·145	1·168	1·191	1·214
44	1·048	1·037	1·056	1·075	1·095	1·115	1·135	1·157	1·178	1·200
46	1·016	1·034	1·052	1·070	1·088	1·107	1·127	1·147	1·167	1·187
48	1·015	1·031	1·049	1·065	1·082	1·100	1·109	1·138	1·157	1·176
50	1·014	1·029	1·045	1·061	1·077	1·094	1·111	1·129	1·147	1·166
52	1·013	1·027	1·042	1·057	1·072	1·087	1·104	1·120	1·138	1·155
54	1·012	1·025	1·039	1·053	1·067	1·081	1·097	1·113	1·129	1·145
56	1·011	1·023	1·036	1·050	1·063	1·076	1·091	1·106	1·121	1·136
58	1·010	1·022	1·034	1·047	1·059	1·071	1·085	1·099	1·113	1·148
60	1·010	1·021	1·032	1·044	1·055	1·067	1·090	1·092	1·106	1·120
62	1·009	1·019	1·029	1·040	1·051	1·062	1·073	1·086	1·099	1·112
64	1·008	1·017	1·027	1·036	1·047	1·057	1·068	1·080	1·092	1·104
66	1·007	1·015	1·025	1·033	1·043	1·052	1·062	1·073	1·084	1·096
68	1·006	1·014	1·022	1·030	1·039	1·047	1·053	1·066	1·077	1·088
70	1·006	1·013	1·020	1·027	1·035	1·043	1·057	1·060	1·070	1·081

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FLANK OBSERVATION COMPUTOR.

By Capt. L. A. Notcutt, M.C., R.A.

THE object of this instrument is to provide a simple means of determining the necessary corrections, when ranging from a flank, to within the accuracy necessary, *at a glance.*

The instrument can be set in a few seconds for any given case of observation. Each observation is then set off on the instrument and the corrections, whether for line, elevation or both combined, can be read off instantly. In the case of the correction for elevation, this is read off in yards but by means off a disc at the back of the instrument this can be converted into degrees, where this method of ordering elevation is employed (the disc being set for the yards of range equal to 5 minutes elevation, taken from the range table). The instrument is compact and may be carried easily in the breast pocket of a uniform jacket.

In the illustration, the instrument appears to consist of a jumble of figures, and the directions given later may appear to be complicated, but the author has shown this instrment to many gunners and after he has explained its use, they have been able to use the instrument at once without any practice *because the principle of the instrument is a graphical representation of the problem produced in minature.* The 'T' shaped arm represents the battery range and line: the 'Y' shaped arm (which is transparent) represents the observers range and line. The two arms can be clamped together at the angle TBO which is read off on the protractor scale of the disc lying between the two arms.

It is obvious that if the corrections had to be read off on the same scale as the rest of the instrument (which is only about 7 inches long) they could not be read accurately enough. To obviate this, the correction scales for battery range and line, and the angle to the burst as seen by the observer, are magnified four times the scale of the remainder of the instrument. This enables the user to read corrections direct to 5 minutes and 25 yards.

The instrument is set by unclamping the screw at the back (see Fig. 2), and sliding the two arms to the correct position for the ranges OT and BT,* adjusting the angle between them so that it is equal to BTO (setting the observer on the right or left of BT according to circumstances) and then tightening up the clamping screw.

Attached to the 'Y' arm is a piece of gut which represents the observers line: it can be temporarily secured at any position required, by means of a clip (see Fig. 1). This gut is moved to reading on

* Caution.—For obvious reasons, the range OT is set under the stud but the range BT is set against the arrow at the top of the disc.

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the scale, in degrees and minutes, at which each shell was seen to burst. Thus in Fig. 1 the gut is set for an observation of 3° 50′ left. The range correction may then be read off direct on the scale on the circle, which in the case of Fig. 1 is about 350 yds.†

When it is desired to bring the burst on the lines of observation by *line correction only*, the user employs the gut of the 'T' shaped arm, holding it as shown in Fig. 1. There is a small glass bead strung on this gut, which is used to represent the shell burst, and is

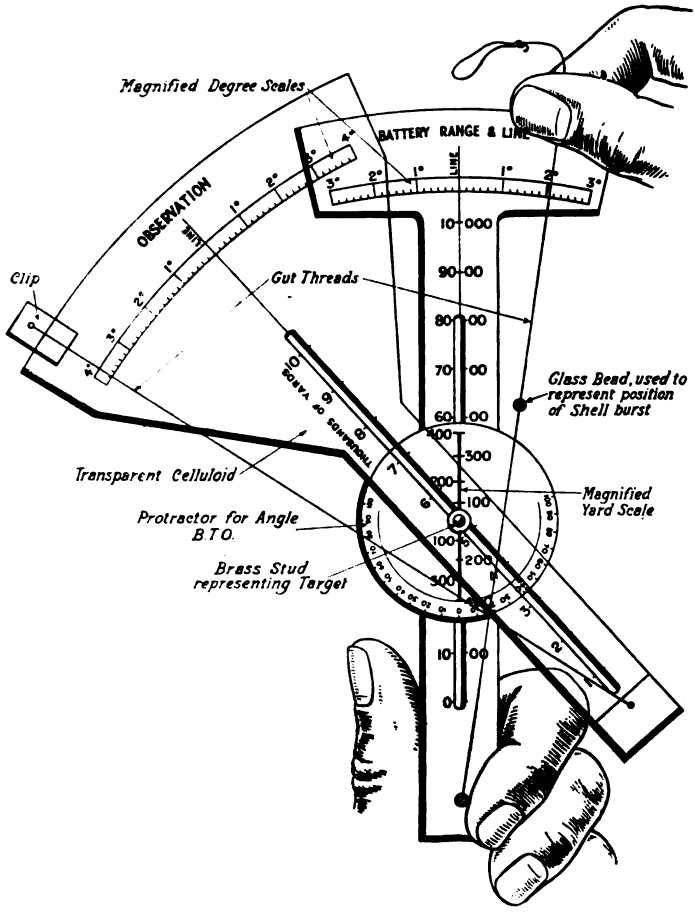

Fig. 1—Front View.

set over the middle of the brass stud (which represents the target) which causes the distance from the bead to the origon of the gut to be equal to the battery range. To determine the line correction,

† It is a point of minor importance, but it is worth noting that had the observation been 3°50′ right, instead of left, the reading on the scale would have been 400 yards over instead of 350 short. This is in accord with fact, but the author thinks this is the only instrument which allows for it. It is not a matter of importance but occasionally it might save a round.

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the gut is then swung out until the bead cuts the gut of the other arm (this represents the shell bursting on the line noted by the observer). The reading on the scale at the top of the 'T' shaped arm indicates the correction necessary.

The last form of correction is combined range and line. There are two cases of this—the first, where the B.C. decides on a definite range correction and requires to know the proportional line correction; and the second is the opposite, where the B.C. decides on a definite line correction and requires to know the proportional range correction.

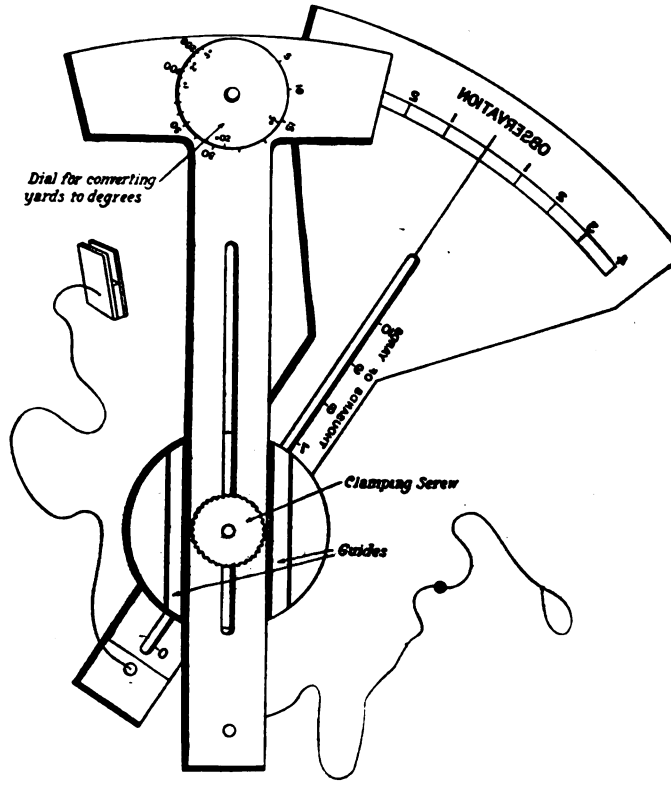

Fig. 2—Back View.

In the first case, the user slides the bead to the amount short or over the target that he thought the shell burst. He then swings the gut out until the bead cuts the gut of the 'Y' shaped arm. The reading on the top scale of the 'T' shaped arm indicates the amount the battery is off for line.

In the second case, the user sets the gut of the 'T' shaped arm at the amount he thinks the battery is off the line either to the right or the left as the case may be, and then slides the bead up or down until it cuts the other gut. The gut of the 'T' shaped arm is then

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swung back to the central position, when by reading the position of the bead on the vertical scale of the circle, he can determine the amount of range by which the battery is short or over the target.

It is scarcely necessary to state that if the observer has obtained a burst on the line of observation to the target, and desires to 'bracket', he must set the clip carrying the gut of the 'Y' shaped arm, to the central position so that it cuts the centre of the brass stud (representing the target).

As stated previously, these instructions sound very complicated, but they are extremely simply to carry out, and are obvious if the rule is remembered—*always presume either the range or the line to be correct, unless you have evidence to the contrary, and correct your Line or Range accordingly*

The instrument has several refinements, such as a means provided to adjust the tension of the gut on the 'Y' shaped arm, without untying any knots.

When using the method of ranging for elevation in degrees, the correction in yards is converted to degrees and minutes by referring to the disc (set for each series) at the back of the instrument. (See Fig. 2).

Messrs. Steward, 409 Strand, will make this instrument for anyone requiring it.

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THE DEFLECTION FACTOR.

By Lieut.-Col. A. J. Peile, R.A.

IN an article on the "Deflection Factor", in the Journal for April 1917, "*Anon*" discusses the accuracy of the factor

$$\frac{OT}{BT}$$

Lt. Rowell, in an article published in the Journal for November 1916, points out that the true value of the deflection factor is given by the formula

$$\frac{D}{O} = \frac{OT}{BT} \times \sec A,$$

where A is the apex angle.

I prefer to write this as

$$\frac{D}{O} = \frac{OT}{BT} \times \frac{1}{\cos A} = \frac{OT}{BT} \times \frac{1}{\sin (90 - A)}$$

Values of $\frac{1}{\cos A}$ are given in the following table and handy approximations are appended which are perhaps as easy to memorize as the percentages of error suggested by *Anon*.

Apex Angle A	Value of $\frac{1}{\cos A}$	
	True	Approx.
30°	1·15	$\frac{7}{6}$
40°	1·30	$\frac{4}{3}$ or $\frac{8}{6}$
50°	1·55	$\frac{3}{2}$ or $\frac{9}{6}$
60°	2·00	2
70°	2·92	3

When using the deflection factor the important point to remember is that it will bring the next shot (falling at the same range) on to the *observer's* line. It will not, therefore, bring the next shot on to the *battery* line unless shots are falling "range".

When the apex angle is large the 50% length zone displays itself to the observer in such a manner that deflection corrections based on factors are apt to be disappointing. It is not suggested, for instance, that it would often be practicable to use it with an apex angle of 70°; the sub-factor is included in the table as a matter of interest. It may serve to remind a flank observer that when shots are falling range and are also out for line, the required deflection may be more than is apparent to his eye and that bracketing for deflection may become necessary.

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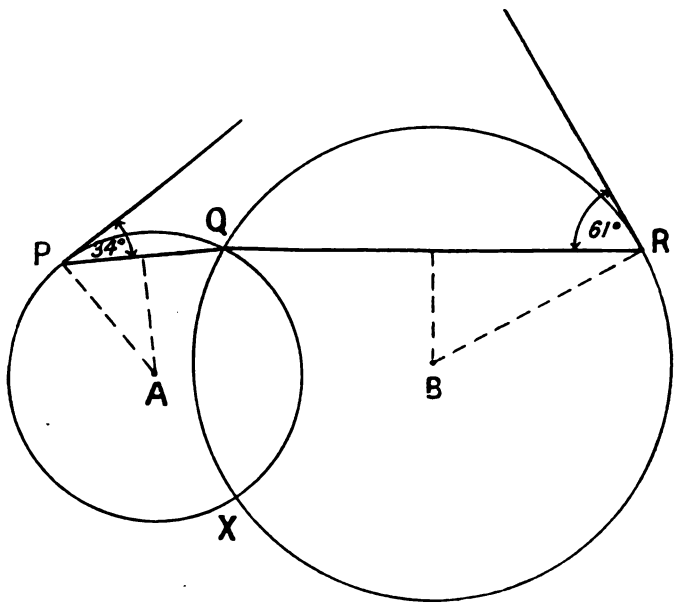
RESECTION OF POSITION.

By Capt. W. H. Fry, M.C., R.G.A.

THE following method has been found most useful in accurately and quickly determining the position of a battery or observation post in the field.

Three points as far distant as possible,—preferably resected positions in our own lines—are chosen (P, Q, R), and the angles subtended at X by PQ and also QR are carefully measured by director or sextant: PXQ = 34° and QXR = 61°, say.

These angles are set off respectively with PQ and RQ and perpendiculars are drawn to the lines thus obtained, which meet the perpendicular bisectors of PQ and QR respectively in A and B. Then A and B are the centres of circles on which lie all the points at which the required angles are subtended: and X (the only point which satisfies the condition that PQ subtends at it 34° and that QR subtends at it 61°) is the location required.



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DISPLACEMENT CORRECTIONS
for Eccentrically Sited Battery Positions.

By Captain G. Sheppard, R.G.A. (S.R.).

WITH regard to Major W. H. Fry's article on this subject in the September number of the Journal, the following method which was shown to me by a French Officer and which is in general use in the French Army seems to me to be still more simple and accurate at any rate where an artillery board is available.

First let the angles to A.P. or A.PS. of each gun for a given grid bearing say 60° be recorded and the arc of the Artillery Board marked in degrees, etc. from this grid bearing as a centre line.

Let the guns be placed as in Fig. 1. No. 2 being pivot gun. Make a tracing of the guns on a piece of celluloid or other transparent material and also mark in the N. and S. Grid line as shown. Turn this tracing through 180° marking it as shown in Figure 2.

Now to measure the range and angles to A.P. for any given target, place the tracing with the pivot gun on the target, being careful to keep the N.S. line parallel to the grid N.S. line. Then placing the arm of the artillery board over any gun will give the range of that gun and its switch from 60° Grid.

The reason is obvious and only depends on the fact that the opposite sides of a parallelogram are equal and parallel.

This method has been tried and found accurate with displacements of 3000ˣ if care is taken to keep the N.S. line of the tracing parallel to the N.S. lines of the artillery board.

It also enables one to use the same artillery board for different positions.

Fig. 1.

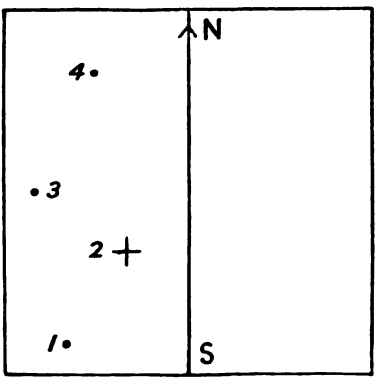
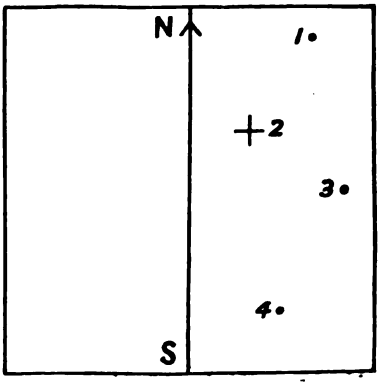


Fig. 2.



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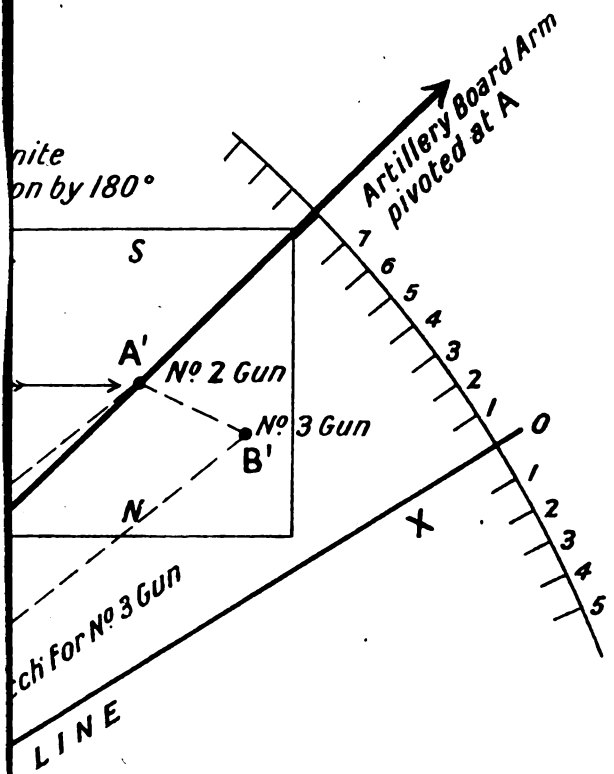

A = ∠ A'AB' since BA' and AB' are 11. The
n pivoted at A measures this angle, i.e. the switch
n to the target at A' from the zero line by being
n at the target end and noting the reading on the
The operation is truly accurate.

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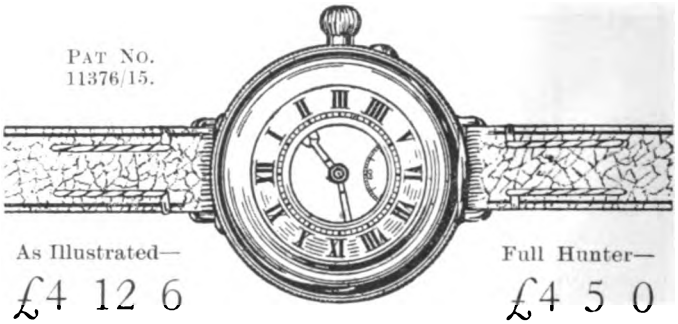

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ALPHABETICAL LIST OF OFFICERS OF THE R.A.

"The Alphabetical List of the Officers of the Royal Regiment of Artillery, and of those retired temporarily and permanently from the Regiment." Compiled, printed and published at the Royal Artillery Institution, Woolwich, S.E., 18. Single copy, 8d. Annual subscription (4 copies) 1/8, post free.

The above publication which has, owing to the great increase in the Regiment, increased from 74 to nearly 200 pages; contains the names of all officers, including those temporarily commissioned since the commencement of the war, with their ranks, honours, and much valuable information to the Artillery Officer.

It is of a convenient size for the office table, (5½ × 7¼-in.) is well printed in clear type on a good quality paper, and should be in every office, especially nowadays, when so many changes are daily occurring.

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HINTS TO SECTION OFFICERS.

By Major J. Lindsay-Henderson, R.F.A.

MANY a young artillery officer must have asked himself and others how he can become a good section commander, and very likely has never got a satisfactory answer. As often as not he has been given a list of duties to be performed, and an appalling list it is, but how to perform these duties well and satisfactorily is the difficulty. This cannot be taught but must be "found out", very often by sad experience and consequent waste of time, and it is with the object of saving time and putting officers on the right track that this is written. All the rest must be acquired by the officer himself who must realise at the outset that he cannot learn too much, nor will ever reach the point at which he need cease learning.

To begin with a Section Commander has to "Command" his section; a command consisting of about 60 men, 50 horses, 2 guns, 4 wagons and large quantity of harness and equipment. This is all entirely under your care and you are responsible to your Battery Commander for the training and discipline of the men, the management of the horses and serviceableness of the equipment. Isn't that a command to be proud of? Well be proud of it; and make it proud of you.

To obtain "Power of Command" an officer must be able to instruct; to be able to instruct requires knowledge; therefore obtain knowledge. Knowledge is obtained first from text books, and then by practical experience. Read and keep on reading until you thoroughly grasp the idea of the drill, then go through it practically by yourself or in company with other officers, and enlist if possible the criticism of a senior to help you out of any difficulties you may run up against. Do everything thoroughly, no detail is too trifling for you to ignore and you will soon find that you are able to instruct and therefore to command, because you know what you are ordering your men to do, and can show practically what is required of them. This gives "Power of Command", and this power increases the more you increase your knowledge.

Personel.

The work of the Section depends entirely upon the personel, and the efficiency of the Section depends upon the instruction and management of your men. Each man has a separate individuality of his own and it is impossible to get the best out of your men unless you get to know each man's characteristics. To do this you must gain their confidence. Take an interest in them off parade, during

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their sports and at other odd times. A little interest goes a very long way. You will occasionally find a usually cheery man become dull and morose, try and find out the cause of this. It may be some home trouble when a little sympathy will help very greatly, or it may be that he is smarting under some more or less imaginary grievance which can generally be easily removed, and the man will at once regain his spirits You must necessarily exercise a lot of tact in dealing with your men and in all your dealings never allow undue familiarity.

On parade be strict in every detail, check at once the slightest tendency to slackness and insist on "go" and "spring" on all you drill. Keep your temper on all occasions, and never swear on parade. It is only better men than you who can afford to do so. Back up your N.C.O's and encourage them in their work, but check any tendency to bullying or favouritism. Always take command of your own parades and do not pass your duties on to your No's 1, but frequently put them on to drill or instruct under your supervision. Do not check or correct them in front of the men but take another opportunity of putting them right. Every one teaches himself more by instructing others than by being instructed so do not confine this to one or two, but let every N.C.O. and man have frequent opportunities and you will perhaps find some talent that you would not have found out otherwise. Make it your chief point to know more about everything to do with the work of your section than any other man. In fact you must endeavour to be the best all round man in your section.

Don't forget that discipline must be taught as well as drill. Your men were probably as ignorant of the one as the other when joining up, so see that every man understands what is expected of him, and do not take things for granted. Punish seldom, but when you do, punish severely, always remembering that anyone can run a battery with crime; to do so without crime is the test of a good battery.

Remember that you have had more education than your N.C.O's and men, and what appears obvious to you may not do so to them. As some will grasp a point more quickly than others, it is advisable to divide your drills into grades, and frame your instructions as if you were addressing the dullest man in that grade. It is often more advantageous to instruct by demonstration than by word of mouth.

Get your men to realise that each one is an important unit of the section just as if he were one of a football team and induce them all to work together for the one end, namely the good of the section and of the battery. They will soon begin to take a pride in their section and in themselves, and when you have reached this stage you will find that more than half your troubles have ended.

Play up to your Battery Commander. Remember that he has great responsibilities and you can very considerably relieve his burden by running the detail of your section well. If you are up against any situation that you cannot cope with yourself, go to him and he will gladly give you advice and see you through, but always do as much as you possibly can off your own bat.

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Have all the details of your section at your fingers end, so as to be able to give any information required at once, and not find yourself in that most awkward position of having to plead ignorance. To an inspecting officer you not only give yourself away badly, but what is worse you let your battery commander down as well. Train your N.C.O's in this also. They are your assistants and must play up to you, and let them realise that they too have responsibilities and authority, but make it your business to know everything that is going on inside your section.

Sink your own inclinations and comfort for the good of the section. See to the welfare first of your horses, then of your men and lastly your own. Your men need relaxation so see that they get it and look well after their comfort in quarters and at meals.

Horses.

Your horses are a very important part of your section and require a great deal of personal attention. Like your men each horse has its own individuality which must be found out by perpetual observation. Don't attach too much importance to reports from your men, but study each horse and arrive at your own conclusions. For example many a horse gets a bad name for vice when all that is wrong is a badly fitted bit. A little observation at the beginning would have remedied this at once, but if the horse is worked constantly with this bit it naturally shows symptoms of vice and will in time become vicious, with the result that an otherwise good horse is lost to the battery. There are many other cases which with careful watching can be as easily put right. Horses must be carefully fed and watched while feeding, so that each horse gets its own feed. Some bolt their feeds and try to grab their neighbours. Others do so because their teeth are sharp and it hurts them to masticate, and thus do not get the full value of their feeds. Thus by observation these and other evils can be remedied. Thin horses should have special feeds, and watch each carefully and if one diet does not improve the condition try another until you know what special diet suits each horse.

Efficient grooming is an essential factor to the condition of a horse. See that all your drivers know how to put their weight into their work and pass all your horses yourself before allowing the men to leave stables. Always keep some of the men in the lines while the horses are feeding and do not leave this duty to the stable picquet. This is doubly essential when feeding out of nosebags, so that these may be taken off as soon as a horse finishes its feed. When taken off, nosebags should be turned inside out to dry, and not thrown into a heap. Unless they are very muddy on the outside, they should be used rightside out and inside out alternately, as this saves the bag from rotting and removes all chance of the bags getting a sour smell.

Once you have teamed your horses, do not change your drivers more than can be helped, as the drivers get very attached to their horses and can generally be relied upon to see that their horses are well looked after, but take care that this is not done at the expense of another driver's pair. Take every opportunity of grazing your horses on roadsides and in lanes, and ease your horses by frequently dismounting the gunners and outriders especially on hilly roads.

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Be very particular about the shoeing of the horses, and see that they go regularly to the forge. While they are there get the Farrier to examine their teeth, and if sharp have them filed. When you have time, take practical lessons in shoeing, paying particular attention to the preparing of the hoofs and the fitting of the shoes.

Harness.

To get your horses to work well it is absolutely necessary that the harness fits well. Pay especial attention to the bits, saddles, breast-collars and breechings, and the folding of saddle blankets. (F.A.T. sections 29 to 32). Have all necessary alterations made at once and always have a hole or two to spare each way in all your buckle straps. Watch carefully that the "V" attachment of the saddle is only put to its proper use and is not used for tightening the girths. Test all the sewn work periodically as the thread rots fairly easily and at all inspections see that every buckle is undone and the verdigris is cleaned off the leather otherwise it will rot it.

Never allow the harness to remain uncleaned even after a long and hard day, and insist on the drivers rubbing all steel work over with an oily rag immediately the harness is taken off as this will save a tremendous lot of time and work afterwards.

Mounted Drills.

As with all other drills take your mounted drills yourself or put on an N.C.O. under your supervision. All instructors should be mounted and be able to demonstrate practically the application of aids. Don't forget that you are probably riding the best horse in the section so do not lose patience with a man on a difficult horse.

When drilling with the battery be careful to pass on the orders and signals from the battery commander, otherwise your No's 1 will get into the habit of watching the B.C. instead of you and you will get into trouble sooner or later.

Gunnery.

All your work in the section is intended to lead up to quick and accurate shooting. You may have the smartest men and the best horses in the battery but if you cannot shoot you are of no use. Gunnery is a science which must be carefully studied and restudied and the ground work principles must be firmly fixed in your mind. Experts have evolved a large number of formulæ from these principles which enable one to arrive rapidly at approximate results, but it must be clearly understood that to make use of these formulæ they must be fixed in your memory and applied at once, as you will have no time to consult a long list of these to find which is applicable, when you are carrying out practice. The only way to acquire this readiness is by constant practice until you can use them as readily as the multiplication table. Use the miniature range for this purpose as much as you can, and give yourself and others conundrums when ever you are drilling your section. You can also get a good deal of practice in your billets or mess, as there ar every few landscape pictures which do not make excellent targets for this work, and if you keep on doing this at odd times you will soon commit these formulæ to memory and

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apply them readily. They are however very easily forgotten so you must keep up the practice. Always remember that these are only approximate, and that it is advisable to check your calculations during any interval in the ranging when you can, and do this by working it out on the longer method if time permits. Avoid using pencil and paper as much as you can and rely on your memory rather than consult the recorder's sheet and you will be astonished to find how quickly you can conduct a series after a week or two's practice. Practice in observation and judging distances must also be assiduously carried out. The former can only be done at practice camps when every opportunity must be taken of observing the practice of other batteries when you are not shooting. It is generally advisable to observe the first round of a series without glasses for if there is any error in line the round may possibly not come into the field of view of your glasses and will be unobserved. Use the graticules of your glasses for correcting line and rap out your corrections as quickly as possible and if in any doubt err on the bold side. Distance judging can be practised anywhere and check your observations by map. Remember that the best artillery targets are fleeting ones, and if you can turn a quick accurate fire on to any kind of target you will have got a long way towards ideal gunnery. You will more than likely be working along with Infantry, and nothing gives them more confidence than knowing that they have got good gunners behind them, who will, and can see them through the toughest job.

Don't go away with the idea that all this is battery commander's work, you may be called upon at any time to take his place so you must qualify yourself to do this. When drilling as a section of a battery or during practice it is up to you to see that your two guns are well and truly served, and if any hitch occurs it is your business to have it put right, and do not worry the battery commander unnecessarily. Follow out at all times the fire discipline instructions rigidly and do not allow any unauthorised variations to creep in. These might do all right in one battery but if you were to be transferred to another which is often a daily occurrence on service, confusion is bound to happen. At drill in the gun park get two signallers and semaphore your commands to the section in preference to using voice command even if only a few yards off, making use of the proper abbreviations. Semaphore signalling is invaluable in a battery and every man should be able to send and read short messages at a slow rate.

Guns and Equipment.

Great importance must be paid to the care of your guns, carriages and equipment. You must know all about the mechanism of the gun fittings, sights, and buffers, and also where the spare parts are carried, so that repairs and jambs can be carried out or put right with despatch. The buffers must be examined regularly to see if there is sufficient oil, and the sights tested for alignment. Examine the wheels periodically, assuring yourself that they are well greased, and have not tightened or worked loose on the axle. If your guns or wagons are likely to be standing for any length of time, keep moving the wheels round a quarter of a circle every day so that the strain is

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not always on the same part of the wheel. Keep the leather work of the carriages well oiled as this is exposed to all weather.

Book Work, &c.

"The" book for the gunner is F.A.T. You must keep reading this constantly. You will always find something that you have previously overlooked or forgotten, and there is practically nothing that affects your work that is not treated on in this book. It slips very readily into the pocket, and a section or two read at odd times, keeps things fresh in your memory, and it is handy as a book of reference at all times.

There is one other book which you will find equally invaluable and that is "Animal Management". If you aspire to be a horse master you cannot do better than follow the advice which you will find in it.

Several suggestions have already been made for giving yourself practical training, but there are one or two other things which you must practice which are rather difficult to arrange, such as grooming and harness cleaning. A good plan is to get up a competition with your brother officers as to which of you can groom a horse or clean a double set of wheel harness best. This is an experience which will stand you in very good stead, as you will be able to speak with confidence on these subjects and know with certainty what can be expected of your drivers. There are other details of your work which can be as readily practised if you will only set your mind to doing it.

Conclusion.

This article has been made considerably longer that at first intended, and many points have been touched on which may seem too elementary for your notice, but as has been said elsewhere, "No detail is too small to be left unattended to", and while making this the apology, the opportunity is taken of emphasising it.

Remember that only a good section officer can hope to become an efficient battery commander, and if anything in this article helps you to qualify as the former, the writer is satisfied, and expresses the hope that in the near future you may be able to add the D.S.O. to your M.C.

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A SUGGESTED SYSTEM OF CO-OPERATION BETWEEN ARTILLERY AND AEROPLANES,

which will enable more machines to use wireless on a given front at once, and will increase the work possible per machine per flight.

CAPT. R. HILTON, M.C., R.G.A. & R.F.C.

THE principles on which the system is based are broadly as follows:

(1). Actual ranging to be done by cross-observation from the ground, the aeroplane merely giving the two observers a "datum" by which to carry out observations on the real target (which neither of them need be able to see).

(2). The Aeroplane, after giving this "datum" to the observers of several batteries in turn, only watches the fire of all of them and does not send any further observations as long as fire is effective.

In the October number of the "Journal" an article appeared advocating the use of Air Bursts for ranging by ground observation and explaining how this could be carried out. The only serious defect in this method seems to be that the accuracy of the whole ranging depends on data obtained from maps.

It is obvious that to calculate where any given shell, which bursts in the air, would have struck the ground it is necessary to know the following facts about it:—

(a). The exact position on the ground above which it burst.
(b). The height of burst above the ground.
(c). The angle of descent.
(d). The line of flight.

As long as these four factors are known it is possible to calculate exactly where it would have burst on percussion, and it is by obtaining those from cross observations on high air bursts that ground observation is possible against a target quite invisible from any O.P. on the ground.

The author of the article referred to states that Factor (1)—the position of the burst with reference to the target—could be obtained by switching both observation of fire instruments from some visible point and clamping them on an agreed point short of the target, by making use of angles measured off the map. I think a much simpler and more accurate method would be to have the first round carefully and exactly "pin-pointed" by an aeroplane and for the two ground observers to clamp on it and use it as their zero line for all future rounds.

This is how the system would work. Let us imagine that the battery is to engage a hostile battery for destruction. The aeroplane goes up and both O.Ps. are warned and stand by with their instru-

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ments unclamped and pointing as nearly as possible in the direction of the target by taking a rough switch angle from the map off some visible point. Of course the O.Ps. should be chosen so as to subtend an angle as near 90° as possible at the target. The aeroplane calls up in the usual way and on the first "G" one round is fired with a time fuze to give a burst 100 to 200 feet above the ground level of the target and short of it.

Both observers swing their observation of fire instruments or directors on to the burst as soon as they see it and clamp on it at zero. Meanwhile the aeroplane has been manœuvred so as to be approximately over the target, the pilot having previously been told the time of flight. He then sends down the exact position on the ground at which the round appeared to him to burst which will of course be the position vertically above which the air-burst took place.

If both observers have been able to clamp on the first round satisfactorily they report so by telephone and some signal is put out at the battery to show the aeroplane that it is not required to send another "g". Otherwise after an interval another "g" would be sent and the process repeated till both observers are clamped on the same known point after which the aeroplane is free to work another battery in the same way till it returns later and checks the fire for effect of all the batteries in turn. It seems reasonable to hope that in most cases only one round would be required to give this "datum" to the two ground observers.

After that the process of ranging would be to continue to fire high air bursts and for both observers to send in:—

(a). Angle of Sight to burst.
(b). Reading right or left of their own zero.

The B.C. could then obtain the height and position of each burst exactly as described in "Ranging by Air-bursts" and continue to fire ranging rounds till satisfied that his M.P.I. was on the target, upon which he would go to percussion and commence fire for effect, at the same time putting out a ground-signal to show the aeroplane that he was doing so.

The latter would have by this time started a large number of batteries each on to their own target in a similar manner, and would now exercise supervision over and note the effect of the fire of all of them without interrupting unless necessary.

In case of any of the batteries being incorrectly ranged he would call it up again and either give it another "datum" round or correct it on to the target himself. However as long as the original "datum" is given without any large error, and has been clamped on correctly this method of ranging should be far more correct than ordinary aerial observation.

If this system were used the whole counter-battery programme could be carried out by one machine in one flight, which would allow all the others to be used for N.F. patrols or reconnaissance of suspected battery positions, both of which jobs have to be neglected far too much under the present system. At present on a normal day the duty of reporting active hostile batteries by NF call has to be entrusted to a pilot who is already engaged in carrying out a shoot, and

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I think all who have tried it will agree that a successful shoot under the present system takes up all one's attention, and that many flashes which would otherwise be located are not. There would be no fear of jambing taking place owing to two machines with the same wave length working at once as long as one of them was carrying out ranging as above and the other (or even two others) confined their messages to sending down NFs and GFs by zone call. For it is only when two machines are continually sending similar signals to one another that risk of confusion arises. The operators of all the batteries concerned could easily pick out their own call and ignore the zone calls while his battery was engaged in a shoot.

Thus three machines of equal wave length could be working at the same time and one of them in the course of one flight could do all the prearranged shoots for the day instead of only getting one of them done.

But by far the greatest advantage of all would be that once the two O.Ps had got a zero-line fixed for shooting on any hostile battery, their own battery by using them could at any time carry out a shoot on the hostile position again without the help of an aeroplane, and by compiling a list of zero lines for all hostile positions fired upon the value of neutralization fire in non-flying weather would be enormously increased.

The main objection to the system is the difficulty of giving a sufficiently accurate location of the burst by means of the clock code—for instance if the round burst slightly south of due west the pilot has to choose between calling it eight or nine o'clock whereas really it was somewhere between them; and similarly if it burst 150 yards from the target he must either call it B or C which is not accurate enough if all subsequent observations are to be based on it. Amplification of the clock-code is suggested, thus BY = 110, BZ = 125, BZY = 135, BA = 150 and so on. Then if the hours were also divided into six so that each subdivision is 5° quite sufficiently accurate information could be given. For instance if the round burst 120 yards short and about half way between 7 and 8 o'clock the pilot would describe it as BYY73 instead of having to choose between B7, B8, C7 or C8, and if 160 yards short and only just south of 8 o'clock he would send BAY75. Probably much better methods than this would soon be suggested but certainly a more exact method than the clock code would be required to give the exact position of the first essential round.

Apart from that small difficulty and the trouble of supplying time fuzes to natures of artillery which have not got them the system would present no trouble in being carried out at all, as no instruments are required by the O.Ps other than those already in posession of batteries such as directors.

At least it seems worth experimenting with owing to the extra amount of work which could be got through if a practical system on these lines could be devised; and all the requirements for experiment would be the issue of some time fuzes to a battery on a practice range at home where the efficiency of such ranging could be thoroughly tested.

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BASHFORTH'S METHOD OF DETERMINING V AND K_v

A note on the previous article published in Proceedings R.A.I. Vol. XXX. 1903.

By Major J. H. Hardcastle, *pac.* (late) R.A.

THE original article was a study of Round 479 from the figures given in Bashforth's own handwriting. A photograph of the page of his note-book was given showing every figure he used in reducing the instrumental results. There were twelve screens in use of which the shot cut all except the seventh and gave records on the revolving time drum. These records were measured accurately as lengths on a continuous spiral. The seconds-of-time record was kept on a continuous parallel spiral and also measured as length.

Owing to the slowly decreasing speed of revolution of the drum the seconds record was not on an even scale, but by an ordinary differencing process the length scale was translated into a time scale reading to five places of decimals of a second.

Bashforth's problem was to fair the length scale of the screen records before translating into time. An examination of the original note-book shows in the left hand top corner of every right hand page a value of Δ^1 and of Δ^2 in manuscript and obviously arrived at by some simple calculation on a slip of paper which slip was thrown away at once as valueless. The figures for Round 479 were:

$$\Delta^1 = 2{\cdot}136$$
$$\Delta^2 = 0{\cdot}036$$

With these as first and second differences Bashforth wrote down an imaginary set of screen records in a column parallel to the actual original unfaired screen records. In the next column he wrote down the difference between the imaginary and the actual screen records, to see how nearly he had guessed the answer. On every occasion he guessed very closely and had little more to do to smooth the record.

My problem when studying the original note-book was to find out what Bashforth had written on the slip of paper he threw away. I failed and wrote to him. He replied that he had forgotten how he did it as it was all thirty or forty years before. Quite recently I was discussing the matter with my mathematical assistant Mr. Mark Segal, M.A., late Scholar of Clare College, Cambridge. He handed me the answer next day, and without doubt it is the right one. As this round No. 479 has been used for many editions now as the stock

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example in the Text Book of Gunnery and this particular point has not been cleared up before it seems of sufficient interest to publish it, so I give it in his own words.

Bashforth's recorded Cylinder distances for round 479 are as follows: The first and second differences (which Bashforth did not insert in his note-book) are added.

Term.	Screen.	Distances.	Δ^1	Δ^2
u_0	1	73·856	2·144	0·036
u_1	2	76·000	2·180	0·030
u_2	3	78·180	2·210	0·040
u_3	4	80·390	2·250	0·020
u_4	5	82·640	2·270	0·030
u_5	6	84·910	2·300	$\bar{1}$·700
u_6	7	[87·210]	2·000	0·784
u_7	8	89·210	2·784	$\bar{1}$·598
u_8	9	91·994	2·382	$\bar{2}$·056
u_9	10	94·376	2·438	0·062
u_{10}	11	96·814	2·500	
u_{11}	12	99·314		
		Total	25·458	0·356
		Mean	2·314	0·036

Bashforth's $\Delta^2 u_0 = 0{\cdot}036$, $\Delta u_0 = 2{\cdot}136$

His $\Delta^2 u_0 =$ Mean $\Delta^2 u_0 = \dfrac{0{\cdot}356}{10} = 0{\cdot}0356$, say $0{\cdot}036$

The mean $\Delta u_0 = \dfrac{25{\cdot}458}{11} = 2{\cdot}314$

Bashforth's $\Delta u_0 =$ Mean $\Delta u_0 - \dfrac{10}{2} \times$ Mean $\Delta^2 u_0$

$= 2{\cdot}314 - 5 \times {\cdot}0356 = 2{\cdot}314 - {\cdot}178 = 2{\cdot}136$

This method is based on the folowing analysis.

$$u_n = u_0 + n\Delta u_0 + n\,\frac{(n-1)}{2}\,\Delta^2 u_0$$

$$\therefore\quad n\Delta u_0 + n\,\frac{(n-1)}{2}\,\Delta^2 u_0 = u_n - u_0 = \sum_{r=0}^{n-1} \Delta u_r$$

$$\therefore\quad \Delta u_0 + \frac{n-1}{2}\,\Delta^2 u_0 = \frac{\Sigma \Delta u_r}{n}$$

$$\text{or } \frac{\Sigma \Delta u_r}{n} - \frac{n-1}{2}\,\Delta^2 u_0 = \Delta u_0$$

Inasmuch as smoothing is done on the assumption that second

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differences are constant, the smoothed $\Delta^2 u_0$ (denoted by δ^2) = Mean $\Delta^2 u_r = \frac{\Sigma \Delta^2 u_r}{n-1}$. δ is then given by the equation

$$\delta = \frac{\Sigma \Delta u_r}{n} - \frac{n-1}{2} \delta^2$$

$n = 11$ gives Bashforth's figures.

The practical significance of the method is that u_0 and u_n are kept fixed and unsmoothed, all the other terms u_1 to u_{n-1} being smoothed

If we take $n = 10$:—

$$\delta^2 = \text{Mean } \Delta^2 = \frac{\cdot 294}{9} = \cdot 0327, \text{ say } \cdot 033$$

$$\text{Mean } \Delta = \frac{22 \cdot 958}{10} = 2 \cdot 296$$

$$\delta = 2 \cdot 296 - 9/2 \times \cdot 0327 = 2 \cdot 296 - \cdot 147 = 2 \cdot 149$$

Comparing these differences, ·033 and 2·149, with those adopted in the article in the "Proceedings," viz. ·034 and 2·144, small discrepancies are revealed. These arise from the fact that the term u_8 is utilised in the latter method, whereas it is ignored in the above method.

Both methods are equally correct or incorrect. It is merely a question of simplifying the arithmetical labour and of the relative importance attached to the terms in the unsmoothed series.

Bashforth's method attaches most weight to the extreme terms u_0 and u_{11}. But in point of fact no particular term or terms in the u series possesses à priori any superior validity as compared with the other terms. The employment of weight to a certain extent vitiates Bashforth's method or indeed any smoothing method based on finite differences applied once only. For this reason a graphical method of smoothing is to be preferred. A graphical method would (with practice) take little time and would at once reveal to the eye the doubtful terms.

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THE USE OF GROSE'S GRID FOR AIRBURST RANGING.

By Major J. Grose, R.G.A.

As a good many officers are using the Grid described in the R.A. Journal of May, 1917, for plotting results when ranging with double line observation, a description of its use for ranging with airbursts may be of interest.

Object.

The object of ranging with airbursts is this: Suppose you have to fire repeatedly on a point T which is not visible to your observers. The O.Ps from which datum points in the neighbourhood can be seen may be scarce, and communication to them uncertain or busy. Therefore a point S (vertically above T) which can be seen from two readily accessible O.Ps is ranged on by means of airbursts. When ranging has been completed and verified, the angle of sight is lowered so as to bring the fire on to T. A number of rounds are then fired, and an air photo of the result is taken. The necessary correction to adjust the M.P.I., is found from the photo. Next time you have to fire on point T, the weather has changed and you are using a different lot of propellant and another gun. So you put the Observers in the same way on to the same point S, and you datum with air bursts; after which fire can be directed on T accurately, because the correction previously found from the air photo will mop up errors due to contours or contortion of map, and errors due to your instruments as well, provided that the same errors occur whenever the instruments are clamped on S. This is a most important point, necessitating exact repetition of the previous clamping. The change of ballistic conditions will have the same effect when datuming on S as when firing immediately afterwards on T.

Method.

The method of ranging with air bursts using the Grid is this:—Two Observers are clamped on S, a point in the air a convenient distance above T, by means of horizontal angles measured from suitable trig points. These Observers give "results" in degrees and minutes right and left; the "results" are plotted as in ordinary double line observation and marked on the grid thus ⊙, with the number of the round written beside it ⊙ 1. The third Observer may be in the same place as either of these, or near the gun (provided

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he can see S, of course). He is clamped on S by means of a horizontal angle like the others, and also by means of the angle of sight, and he gives "results" in degrees and minutes above or below S. S should be chosen at such a height that this Observer can see a bit below it for the low bursts, but also so that he has some distant fixed object in the lower part of his field of view. This is important, to ensure his getting on to exactly the same spot another time by getting the same fixed object at the same point in his glass. Call this Observer H, and B the Battery. Make a scale of minutes as measured at H for use on the grid as follows:—

$$10 \text{ minutes at H} = \frac{HS}{BS} \text{ minutes at the Battery.}$$

A square on the grid = 10 minutes at the Battery. Lay a piece of paper on the grid and mark it accordingly. Using this scale put in the observation from H by a narrow – so ⋀ | ⊙ 2 Means 20 minutes up, the length of the arrow being 20 minutes on your paper scale. ⊙ 3 Means 30 minutes down in the same way. The point of the :| ⋁ arrow indicates the place where the trajectory cuts the horizontal plane of S.

After adjusting your fuze to give bursts as near as possible to S, you range for elevation using the points of the arrows on the grid.

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BRAIN v. RULE OF THUMB.

By Major D. S. C. Evans, R.G.A.

A COPY of the R.A. Journal of October 1917, having recently come to hand containing an article entitled 'Machines *v* Head', I feel constrained to write a few remarks which will, I hope, help to eradicate the false impression created by the said article, anent the use of so-called machines.

The author states that the main objection to the use of machines is that 'the man who uses an instrument to solve a problem does not use his brains'. In place of instruments, the use of various rules of thumb are advocated: but how are these rules of thumb arrived at; but by the use of machines and instruments?

He who uses a machine to invent a rule of thumb may be using his brain, but he who uses the rule of thumb is merely over-taxing his memory in order to avoid the use of an instrument which he is probably incapable of comprehending.

In connection with the simple little problem of resolving the velocity and direction of the wind, the author gives a table containing 29 figures which 'anyone can carry in his head'. But why carry them in one's head? Surely it is better to realise that these figures are merely obtained from some sort of instrument (probably a slide rule) and to know how to obtain them for oneself. Is it not wiser to obtain the same result with equal speed and, if necessary, greater accuracy, by intelligent use of first principles of trigonometry, instead of endeavouring to memorize a mass of figures, which are probably not understood and certainly cannot be checked unless the manner of their discovery is understood?

It is also suggested that a table of sines to two places of decimals could be inserted in a spare page of the range table: but why trouble to write it down there when it is all ready for use on the slide rule?

The great point of the whole controversy is that although the slide rule is a weapon capable of greater accuracy than that normally required in the field, it does not necessarily follow that it must always be used to this pitch of accuracy: a slide rule may be used just as conveniently and considerably more rapidly for approximate calculations than most rules of thumb. Again, one slide rule will take the place of all the rules of thumb ever invented in connection with gunnery. Its intelligent use obviates the memorising of half a dozen to a dozen rules of thumb of doubtful accuracy and tedious length.

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Who can draw out a Grose's grid in 'a few minutes' (probably 3 minutes in the field) without using a slide rule?

As for the methods advocated for calculating the factor $\frac{E}{O}$ and $\frac{D}{O}$, it would seem that some one had gone out of his way to invent a series of rules destined to give inaccurate results, and then to invent further rules for counteracting these inaccuracies, thus finally presenting one with a problem involving fine operations and the memorising of at least eight sets of figures.

The whole problem may be solved in two operations on the slide rule providing its proper use be understood, in a quarter of the time and with twice the accuracy, if such is required.

I would advocate adequate instruction in the use of the slide rule to all embryo gunner officers, and the abolition of all rules of thumb except those of the utmost simplicity and speed, such as the 12 rule for example. No collection of accessories is required: merely one slide rule, which can be carried just as conveniently as a prismatic compass or a pair of binoculars.

Modern gunnery is undoubtedly scientific—if it is gunnery at all—and the sooner science is intelligently applied to its practice the sooner will those two essentials, speed and accuracy, hitherto regarded by so many as incompatible, become possible.

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FLYING.

A Lecture delivered at the Royal Artillery Institution, on Thursday, 17th January, 1918.

By Colonel A. C. H. MacLean, The Royal Scots & R.F.C.
Commandant R.F.C. Armament School.

(Illustrated by Lantern Slides).

Major-Genl. W. F. Cleeve, C.B., (Commandant R.M. Academy) in the Chair.

THE CHAIRMAN: Ladies and Gentlemen: It is my pleasure to introduce to you Colonel MacLean of the Royal Flying Corps, who is going to give you a lecture on a subject he is very well able to speak about. I will ask him if he will kindly proceed with his lecture.

Colonel MacLean: Ladies and Gentlemen: A certain amount of what I am going to tell you to-night is confidential and therefore goes no further. In aviation it is a continual war between ourselves and the Hun as to who gets the best aeroplane; and the best aeroplane means the fastest aeroplane and the one that can fight best. It is an extraordinary thing that when experts are thinking about a design a hint will probably put the other fellow on the track. Therefore mum's the word.

To-night I shall speak for about half-an-hour and then show you some slides to give you an idea how the pilot is trained; having trained him we find him overseas and what he does there. We start with the pilot himself. He is caught young and is placed in a Flying Corps Cadet Wing. He does four months there and in that time we try to pack as much discipline as possible into his little mind. Having left there he proceeds to a school of military aeronautics and there he learns all about engines, the actual aeroplane, wireless, bombs, signalling and half a hundred other things. He does that for six weeks and then he goes on to the Armament School where he does intensive gunnery for three weeks, the theory being that it is no good flying unless you can shoot. You may fly beautifully but unless you can use your gun your number is up. Therefore we teach him gunnery in an intensive fashion so that when he goes into the air he automatically can clear a jamb. Having gone through these three stages he then proceeds to an aeroplane squadron where he learns and is taught how to fly. Now teaching flying is very

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simple. One of the first things you have got to do to your pupil is to impress upon his mind that he has to do what he is told because you take him up dual-control, that is to say he puts his hands upon duplicate controls and you show him how it is done, and if he is at all stubborn he may kill you both. Therefore you try and impress upon him that it is necessary to do what he is told. There have been occasions when it was necessary to hit a boy very hard on the head. But it is essential, and it is one of the things that young instructors forget to impress upon a pupil that a disciplined mind is essential for a pilot. That is why we put him through cadet wings with a view to disciplining his mind. He first of all goes up in a slow machine with his instructor. To speak of a slow machine is possibly a misnomer to you because it means flying at about 50 miles an hour. If you will imagine that my stick represents what we call a joy stick—the control lever—of an aeroplane you will find the pupil sitting there and I represent the instructor sitting behind with the joy stick, and he has got a duplicate in front. He feels the instructor controlling the aeroplane. He does that probably for three or four hours and up to five hours. It depends entirely on the personality of the pupil. Some pupils learn quickly and others are very slow and are what we call "hammer fisted". Supposing he is an average youth and he takes about three hours of dual control instruction he is put off on his own and he goes what we call "solo", it is an exciting moment the more so possibly for the instructor than for the pupil. We have got a little pet name for officers under instruction in aviation and that is the simple word "Hun". They do not like it but they have to lump it. The "Hun" pushes off on his own and gets into the air, and feels for about ten seconds very much afraid, and after that he thinks "What about Hamel now?" It is extraordinary when you feel the aeroplane controlled by yourself for the first time. What an exhilarating feeling it is! You have the engine behind you or in front of you and you are the man who controls it. It is a very exhilarating feeling and if you do not lose your head you will be all right, but if you do lose your head you will lose your life. But we do not put them up until we are quite certain that they will not lose their heads. The pupil does that for about three hours in which time he has had to land about 15 times at least, because landing is the difficulty in flying. We have a proverb in the Flying Corps, "Any fool can fly but it takes a flier to land". It is very true. If you imagine my stick is an aeroplane flying level, and the pilot decides to come down and he glides down, and he forgets that the earth is immovable and does not alter the path of his machine, he is going to hit the earth a nasty bump; whereas if he flattens out he secures a landing. Having done his three or four hours and his 15 landings he then proceeds to a higher training squadron where the same type of instruction goes on with slightly faster machines at about 60 to 70 miles an hour. He does three or four hours dual control and he is shown how to loop, to tail slide, to spin and to roll. In this higher type of machine we have a telephone fitted to the youth's head, and he has got it there the whole time, and the instructor has only to murmur sweet nothings to him down the telephone and he will pick them up; so that when he is in the middle of a loop

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and has done it badly the instructor will tell him how he has gone wrong, that instead of going down in a nice circle he has probably gone up, and he tail slides. There is no danger if he is high enough. I might say here that the height at which aerobatics are done—that is what we call such things as looping the loop—is about 2,000 feet, so that there is plenty of time to recover. That is the new form of intensive training. It has just been completed and it has quickened up the production of pilots by about 30 per cent of the time spent on them. It is harder work on the instructors but it makes infinitely better pilots. Another important thing in this intensive training that he gets now is how to land tail to wind and across the wind. You have probably all seen a bird landing on the ground. Take a duck for instance. You notice the next duck that lands on a strip of water and you will see he will turn head to wind. The reason for that is that his progress through the air is slower and he does not hit the water with such a flap. It is exactly the same thing in flying. Landing across the wind is very important because aerodromes overseas are very small generally and you cannot always land head to wind, and you have a house or trees or something in the road. That is all taught in this intensive training by instructors by telephone and with a dual control machine. There was a very interesting case the other day at Salisbury Plain. I got two United States Officers representing the two types of youth of America, one from Yale and the other from the commercial side of life, and they were both youngsters of about 19 or 20, and I put them into the same squadron, and they received identically the same instruction. When the youth from Yale had done 2½ hours of dual control he was pushed off on his own and at the end of five hours he was flying upside down. You could not stop him; he was a splendid boy. The other young man flew upside down in ten hours. Upside down flying is merely an amusement, but it is quite useful. That is only done by the aid of this intensive training.

We have got our young man by now pretty well through his flying. At the same time he has got to be taught other things. At this stage of his career he will instinctively have fallen into one of two categories, either a fighting pilot or an artillery pilot. It means in the case of the fighting pilot he is a youth that has got more heart than brains, and in the case of the artillery pilot that he is possibly a youth who has got more brains than heart. It is a simple division but some fellows automatically like fighting and others do not. The fighting pilot gets the following training. The intensive training still goes on and he has aerobatics in a much more intensive way than the other pilot; in other words he has got to chuck his machine about in all attitudes and has got to practise fighting. Now the practising of fighting in the air is very realistic because we take pictures with a camera gun of two machines scrapping. Imagine that my two hands represent two machines. The finger represents a gun in each machine with a camera attached, and when these two machines are fighting and revolving round each other for an opportunity to fire they use their sights and open fire, and by pressing the trigger they also take a photograph of the other fellow's machine. When they come down the pictures are developed, and you can tell

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whether or not, if there had been bullets in the gun, the enemy would have been down or not. It is a very good invention and has done a tremendous lot to aid aviation. The most famous flier of the French Flying Corps used one always. He had a certain type of gun and he had a bigger gun on his machine and the third gun he carried was a camera gun, and they were synchronised, so that if he used the smaller gun, which is equivalent to our Vickers, he took a picture. If he used the bigger gun he took two and the same when he had used his third gun. When he came down he developed his picture and criticised his own fighting. That flier brought down 52 machines before he was killed. That is our means of teaching fighting in the air.

Now we come to the artillery pilot as to ranging guns and the training there also is intensive. The pupil goes down to an artillery school, and there he is taught to co-operate with artillery, and how to send signals by wireless and direct the fire I will show you on the screen presently how we teach him. We have then got our "Hun" pretty well ready for the Front, and now, having passed all these tests, he puts up what we call wings and is ready to go overseas as a fighting pilot or as an artillery pilot.

I should like to say one word about the man—the Royal Flying Corps mechanic. He is caught young; in fact we catch him about 15 years of age now if the parents will let him come, and we send him to a flying school of instruction where we teach him a trade. That is just started. At the present moment the mechanic of course is attracted to the Flying Corps by good pay, and we like to get good craftsmen. A good cabinet-maker becomes a rigger who looks after the aeroplane, less the engine. A fitter is a man who looks after the engine less the aeroplane, and a fitter has generally been a motor mechanic, or something like that, who understands engines. They join a squadron and they are put in charge of aeroplanes and they have to run them, and the pilot has to fly them. That is roughly the training of the man.

Well, we have got the pilot and we have got the man overseas. Now, overseas we find that the organisation of the Flying Corps is very simple. It is composed of brigades. There are five brigades in France and each brigade is composed of two wings; each wing has three, four or five squadrons; each squadron with three flights. You find a flight which is composed of six machines and six pilots, and if it is a two seater squadron it has six observers. An observer is an officer with half a badge because he cannot fly—he has not two wings. They are an extraordinarily fine body of young men. They go up and trace with their pilots and they go and fight and take photographs and range guns. In this two seater squadron, after he has done about six months serving, an observer gets a chance of coming home and learning to fly. They all do come home because a pilot is top dog. The observer when trained as a pilot is a very useful man. He knows the job before he learns to fly and he applies all his previous knowledge when he does know how to fly. In fact the present Chief Instr. in Tactics at the "Shop" was one of my observers; he used to go straight at 6.000 feet. That means doing a flight straight ahead without doing any turns. He used to fly a machine and he taught

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himself to fly straight 6,000 feet. So much for the observer. In a flight consisting of six machines you have a flight Commander who is a captain, and he is generally about 19 years old. He is paid £500 a year, and he commands five other boys aged 18 to 19 who are pilots. He has got 32 men mechanics, and he has got a motor car, he has got tenders and lorries; he is a complete little unit, and it is a splendid billet—the finest in the Flying Corps. Three of these flights make a squadron commanded by another old soldier, aged about 21. He is a Major getting £600 a year and is a very important individual because he attends conferences generally of nothing but Generals. So much for a squadron.

They have a very happy life and it is a very exciting one. When they are fighting they are all out, and when they are not working they are very comfortable. We have horses to ride to keep us fit, and we build our own tennis courts, and we play football. We find a squadron of an artillery wing has the following functions. It has got to range the guns of the Army Corps. It also takes photographs of the immediate front; it does tactical reconnaisances of the immediate front—that means the front of the Army Corps up to about five miles behind the lines; it also takes part in small bombing raids and does contact patrols. I will tell you a little about each of them. The artillery work of course is the most important, and now it has reached very high perfection, I think. In 1914 we started with Very's lights. A green light meant short and right, and a red light which meant over and to the left, or something like that. Then we went on to electric lamps, and then to wireless which we have now. If you will imagine that the light above you represents an aeroplane, and this object on the table represents a hostile Hun battery which has been located and has got to be knocked out, and the lantern represents the battery, the shoot is pre-arranged, and the fellow goes out in the morning knowing what battery he has to look for and knock out. He gets his height, about 6,000 or 7,000 feet, and calls up the guns. The last time I was out there was a little incident which will explain the wonderful co-operation between the two forces, because it really is wonderful. This particular battery was the headquarters of some heavies. I went up about half-past twelve, and the Colonel commanding it had his shrapnel helmet on and was sitting 20 feet below the ground. He said that if we did not mind being strafed would we stay to lunch, and we accepted. Sure enough the morning hate started at one o'clock and the stuff began to come over, and we were quite happy. About three minutes after the first one had come the telephone operator said "She is calling up". That meant that the aeroplane was calling up. The telephone operator was in communication with the ground wireless station, and sure enough the aeroplane was there, and had called up and sent down the map reading of the hostile battery. All the Colonel did was to take his receiver up and ring up one of his batteries and give them the map reading and tell them to knock it out. This battery started, and we got the readings of the observer down the wireless, and they were passed down the telephone wire to the battery, and in about ten minutes down came the signal O.K. That meant that that Hun Battery had gone to glory. In the Flying Corps we never send an O.K. message

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until we are sure of it. I will show you afterwards photographs taken of gun emplacements before and after they have been treated by our heavies ranged by wireless. In this morning's paper you find a description of the last raid over one of the towns in Germany and there we actually took the trouble to stay after we had bombed the place and take a photograph of it, because we wanted absolute proof. We always prove it by photography; the camera cannot lie So much for the ranging of guns by aeroplanes.

The next thing is reconnaisance of the immediate front. A squadron Commander is responsible to the Corps Commander to give him early information of any changes that have taken place either in trenches or in battery positions or anything like that; so he usually sends out a reconnaisance in the morning and one in the evening to have a look round and report any changes. Then we have contact patrol. Now contact patrols are a new idea started by the French at Verdun, and we have perfected it. Please imagine that these officers standing out at the door represent the 1st Battalion of the Royal Scots, and they are going to take this screen, representing the third line of the Hun trenches, and our old friend the aeroplane is up above *here*. Now you have heard of such things as "Held up by barbed wire" or "Held up by machine guns". The first battalion of the Royal Scots takes the first two systems of German trenches all right but then they find a nasty little nest of machine guns and they say "Where is the jolly old aeroplane"? They look up, and by a pre-arranged signal they let the aeroplane know what has happened, and what they want. This fellow who is flying at about 500 or 600 feet—that is only about 200 yards, and it is very close to the ground, and he is shot at like blazes—will read the message and then pin prick an enlargement of the system of the third line trenches showing exactly where the trouble is, and then will fly back about a mile and a half, which takes about a minute, to brigade headquarters, and then drop the message. The Brigadier picks the message up and rings up the gunners, and in five minutes the 1st Battalion of the Royal Scots goes on and the machine guns have gone to blazes. That is an absolutely true picture of what happens. It is extraordinary how immune the fellows are on that job—how immune the aeroplane is from casualties. There are very few cases of aeroplanes being lost on contact patrols. That contact patrol work produced the sport of aeroplanes firing at infantry in the trenches. There is an authentic case last year of a young pilot aged 18½ who got down to within 50 feet of a line of trenches and made the Huns hold up their hands, and he flew back and landed near the Brigade Headquarters, and told them what had happened. He said "The Huns have got their hands up, and it is my trench". The infantry went forward and took the trench, because the pilot had gone back and again compelled them to hold their hands up. The trench was named after the pilot because they were so pleased. Then bomb-throwing by an artillery squadron is very minor. It consists of bombing the ammunition dumps, and keeping the Huns generally on the *qui vive*. It is an amusing thing, and young fellows like to drop bombs. I remember last Christmas but one, two of my youngsters came and asked if they could do a reconnaisance. The clouds were

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about 300 feet up, and of course it was silly, but I heard the night before they had arranged a little stunt with some of their friends in the trenches. It cleared up a wee bit and these boys looped the whole way to the trenches at 1,000 feet, and then flew over an Archie, a German anti-aircraft gun, and one boy got to 3,000 feet and they started on him. He threw three bombs and then looped the whole way home. That is bombing.

Now we turn to the fighting squadrons. Of course the fighting aeroplane is the most important unit in the whole Army because it guards the artillery machines in doing their work. If they are not guarded the Hun comes and sweeps down on them, and the guns cannot be ranged, and the barbed wire is not broken and the battle does not take place. It is a very important unit, and a very gallant one. That is the other division. We have had the artillery wing—the fighting wing is the other division of the Brigade. It is called the Army wing actually. The Army wing consists of one or two fighting squadrons and probably a bombing squadron—the fighting squadron first. The role of a fighting pilot is to down the other fellow. It is just the same as in the Navy where if you want to keep afloat you must sink the other ship. It is absolutely true in the air. There are various ways of sinking an aeroplane, one is by fighting it in the air, and another is by bombing it on the floor. As regards fighting you will find squadrons go out on what are called offensive patrols, and 12 machines fly in formation. If you recollect the flight of geese they fly in a wedge, and it is a curious thing that every goose in that flight can see the leading one by simply turning his neck. It is exactly the same in formation-flying in aeroplanes. It is so arranged that every pilot can see his leader and the leader can see all his men and can signal to them. That is flight in formation. They fly at slightly different altitudes, the leader at 7,000 feet, the next two men at 7,200, the next three at 7,400 feet, or something like that, the idea being to give them room for movement. Their role is to find the Hun and down him, and he generally goes home. If he thinks he has a chance he has a try at it, and if he does not he goes home. He generally goes home, but we have got to catch him on the way home. The leader is a Flight Commander, and an experienced fighter, and he has to make up his mind whether or no he will attack. He sees a Hun or two Huns and says "That is not good enough," because he knows very well they are ground bait. These ground bait are very slow old machines that can dive very fast, and go home like blazes; but 15,000 feet up there are probably 15 Huns hoping that we will be attracted by the ground bait. However, if he signals an attack the whole formation dive at the Hun, and they single out one machine and it goes down. They have to keep in formation. If they get scattered they will probably lose two or three machines. The whole art of fighting is to keep close. There are various types of fighting in the air. The chief form now is what we call a dog fight, machines all worrying round like anything. If the machines keep together it means that three or four Huns go down, but if the machines do not keep together it means that three or four of ours go down, and there is no doubt about it. I think that in the biggest battle overseas there were 102 machines engaged. I

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think the Hun had about 80 machines and we had 20 or something like that, and we won, and the others went home. So much for fighting. It is a very gallant pilots job, and he has got to have infinite resource.

Now to give you a slight instance of the tactics in the air of some of our best pilots we will take Ball, VC., D.S.O., M.C. He got innumerable Huns and he was one of the most gallant boys we ever had. The way in which he used to attack was this. He went out alone and always liked to be on his own. He was a very fine flier and first class shot. If you will imagine that the whole of the electric lights in the room represent a Hun formation, flying towards me on some job or other, that is what Master Ball wanted. He used to be dodging about among the clouds. He would take cover in the clouds just in the same way as infantry would take cover in the folds of the ground. He used to be taking cover on the edge of a cloud and would see these fellows and get ready. One of his tricks was this: He would come down for about 1,000 feet above the Hun and then he would fire two or three Very's lights, and the Hun would say: "My God, what is up," and all look up. Now when you look up in the air you nearly always rudder instinctively and your aeroplane goes off a wee bit, and the formation is slightly broken up. That is what he wanted. Well, he did the last thousand feet in about half a second and came down on top of the Hun who was the most straggled, and he never shot at a distance of over 30 yards—15 yards was about his usual range—and about ten rounds in one burst and that Hun went to blazes. Then he used to go off again and get into the clouds and look for somebody else. He did that very successfully. Another method of attack I will not tell you about because it is not known yet. That was a very favourite one that Ball evolved.

Now you have all heard about bombing. It is very useful because it destroys aeroplanes on the ground. The bombing squadron is part of the Army Wing, and the Army Commander probably talks to the Flying Corps Brigadier and says: "Look here, we will bomb somebody to-morrow; down in that railway station". Away they go; they do it in the daylight generally, and they fly in formation escorted by scouts. Bombing machines have generally an observer with a Lewis gun, but we send out scouts too. One particular bombing raid I am thinking of happened three weeks ago just about the time that people were leaving London, as the moon was up. This bombing show went out to a certain aerodrome where the Gotha lived. We sent out 22 machines with bombs at 11 o'clock in the morning guarded by scouts. They bombed this aerodrome considerably and came back and had lunch, and went out again. They were so pleased that they all asked to go out for the third time before tea, and they did. But on the first two trips they could not make out the inactivity of the aerodrome. On the third trip they discovered the reason. The Hun had wheeled his machines out of his shed and painted them to look like cows. Therefore on the third trip they went for the cows, and they did them in. That is really why London was immune last moon. So much for bombing in the day time.

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Night bombing is done considerably by both sides and I think we do most of it. Flying at night of course is not as difficult as you imagine, but it is a good thing in this way that it makes the aeroplane immune or more or less immune from anti air-craft fire. They can put a barrage up and hope he will not go through, but it is impossible to deny any area to any pilot by gun fire, if he takes the risk. If a pilot has made up his mind and shuts his teeth he can go through any barrage. The reason so few Huns go through our barrage is—this is my own opinion only—that it is an awfully long way back to the Fatherland, and as long as they have dropped a bomb in England they can go back and say they have done in any amount of munition factories. Our men do not mind the gun fire in the same way that the Hun does. Their objective at night is generally some ammunition dump. They go down comparatively low, about 1000 feet and under 300 feet sometimes, and they drop their bombs. Of course bombing a big dump is not as pleasant as it may seem because if you do get the dump there is a big explosion and you have a most awful time of it in the air. However, it has got to be done, and it is done. Objectives to be bombed are dumps, railway stations and camps and bivouacs and you must bomb towns containing munition factories. Well, so much for the bombing squadron.

Now we will have the lights out and I will show you some pictures. A number of slides were then shown on the screen and explained by the Lecturer.

The Chairman: Would anyone like to ask the Lecturer any questions on the subject of his lecture, or like to add any information? (A pause). I am sorry that no one has come forward to ask for enlightenment on some of these points. I am quite sure there are some here who know something about it, but perhaps they hesitate to come forward. However, it remains for me to ask you to accord a vote of thanks to the Lecturer for his very highly interesting and explicit lecture.

(Carried by acclamation).

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"INITIATIVE."

By Capt. C. H. Brittan, M.C., R.A.

THE modern developments in war (i.e. the increase in the size of the armies employed; the extent of the battlefields and area of operations; improvements in guns, rifles, etc.) have had many results, but the chief has been on the influence of command.

In the modern battle, after active operations have once started, even with the means of communication which we now have at our disposal, commanders can never be certain of receiving orders from the rear. All success is then dependent on the clear-sighted action of individual groups, or men. This applied in the moving battle equally to all arms. Self reliance and initiative are therefore essential in all ranks. Everyone who has been brought into contact with modern military training must have met the word initiative. Our training manuals are full of it, and impress upon us the advantages it confers upon its possessors. The importance of cultivating it in subordinates is insisted upon. I think we are all apt to talk of "gaining the initiative", but very often we have but little idea as to how the desired end is achieved. Let us then consider what initiative is, how it is obtained, and to what use it may be put when we have it.

What is initiative?

Resolution is the author of action; Initiative its nutriment; Independence its guard against interruptions. Initiative is therefore the food of action, which is also dependent upon resolution and independence. It is not easy for the average man, when he hears other opinions, to be quite clear in his own mind what he intends to do. To clear the ground as to the nature of resolution to be taken, it is best to carry out a process of simple self interrogation: "What will the enemy do? What must, in that case, hurt him most?" Sometimes time or excitement prohibit self interrogation; a resolution then becomes a matter of instinct.

The second factor, Independence, is apt to be confused with self-will. It must therefore be borne in mind that the first risks the person for the sake of the cause; the second, the cause for the sake of the person.

The third factor, Initiative, is clearly not all of one kind.

A general may force his enemy to conform to some movement, either because his army is in a superior state of readiness, or because it can move more quickly, or because he has made a better appreciation of the situation than his opponent. A commander and his army

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may thus gain the initiative by more perfect preparation for war, by greater mobility, or by superior generalship, or by any combination of these three. This form of initiative is obviously different to that shown in the action of some subordinate, who, seeing a favourable opportunity, seizes it without waiting for specific orders.

We can, therefore, I think, put Initiative into two classes: that of the commander, and that of the subordinate.

How initiative can be obtained.

Let us consider the first class mentioned above.

The power of the commander to anticipate his enemy, as I have already stated, depends upon the readiness of his army for war; its mobility; and his own capacity as a leader.

Now, of these three, the tendency of modern developments is to increase the importance of the first—readiness for war.

Up to the time of the Duke of Wellington, little, if any, peace preparations were made. The peace garrisons formed the army in the field when required, and the only training they received was practically confined to the development of the fighting capacity of the smaller units. The Duke appreciated this fact, and he prepared his army during the actual course of the war. This was the reason for the delay at the beginning of the Peninsular Campaign, as he would never be forced into any enterprise for which his army was unfitted. In consequence of his victories, the years of tedious preparation were forgotten or ignored, and we were almost the last of the European nations to take up modern preparation for war.

Experience has shown, in all modern campaigns, that the nation which has given itself up most seriously to the preparation for war, has gained the initiative. The struggle to gain it caused Europe to become a standing camp. The desire to anticipate the enemy was the utmost thought in each nation's mind, because they realised that a power that succeeds in taking the field in complete readiness, while its opponent is still in the throes of organisation, will, therefore, have gained an advantage which, if pressed, may well be decisive—as was seen in the Bulgar-Turkish war. Time is to the modern military organiser what cost of production is to the business organiser. Obviously the business of preparation is not entirely military: it must depend upon the efficient co-operation of the nation as a whole. With ourselves as an insular power, the problem is more complex. Our seas make it almost impossible for us to anticipate our enemies, so that we have to take every possible step to reduce to a minimum the time during which the initiative may be with our opponents. From this it will be seen that initiative in its broadest sense depends, from the commander's point of view, mainly on the conditions under which the army is able to take the field. The gaining of initiative is often spoken of as of the gaining of a victory. Although it confers great and obvious advantages, and is a long step on the road to victory, yet where it has been regarded as a goal to be reached at all costs, the consequences have been disastrous. In war, as in any other business, the means must be adequate to the end. In the Bulgar-Turkish war, it was largely a straining after initiative with

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inadequate means which was responsible for the dramatic collapse of the Turkish Army. They had been taught to realise the advantage of gaining the initiative, but had failed to realise that it is not gained by merely moving towards the enemy. Therefore, do not let us confuse initiative with simple "Go at them!" An attack may be a precise example of want of initiative. It is of little value unless it is applied with judgment and carried through with sufficient power.

Let us now consider the second class of initiative,—that of the subordinate.

This quality in the subordinate is a comparatively new feature, and as far as one can learn from history, it appears to have been "made in England". The first systematic training which seems to have taken place to foster self reliance and initiative, was under Sir John Moore at Shorncliffe Camp, where the famous Light Division (43rd, 52nd, 95th Foot) were trained. Their deeds in the Peninsular War are sufficient proof of the value of their training, and Wellington said of them, "They were unsurpassable, perhaps never equalled." As an example of their capabilities, before Talavera they marched 62 miles in 26 hours, in the hottest season, carrying 70 lbs. on their backs, and there were only 17 stragglers.

The secret of the whole matter was the real government and responsibility of the subordinate, each in his own sphere, but it was not till 60 years later that the changed conditions of war showed the necessity for such training throughout the army; if the habit be once acquired of never being trusted with authority, even in a limited degree, and of always leaning on the mere dictation of others, it becomes extremely difficult to shake one's self free from it, and either to assume responsibility and authority, or to delegate power. A readiness to assume responsibility, if necessary; a knowledge of when to assume it, and a capacity for guiding others, are essential among officers. The same applies equally among the lower grades, of giving them a definite sphere of duty, and making them responsible for it. The allotment of a definite sphere of duty, to the commanders of smaller formations, was one of the chief points in favour of the introduction of the 4—company system, which was introduced just before the present war.

The uses initiative can be put to.

Let us be quite clear that the initiative of the commander is a means to an end, and a very valuable means,—but not the end itself. Unless it is gained sooner or later, no decisive results are possible, but at the same time it is, by itself, in many cases the cause of blundering. It cannot be gained by merely advancing first or by anticipating the enemy at some strategical or tactical point although either may often be a step towards gaining it. A commander has gained the initiative when he can strike his enemy and keep on striking him, leaving him no breathing space for a counter offensive. This higher form of initiative is of little value unless it is backed by the power to strike, and strike effectively.

At the present time many are asking where the development of initiative in the subordinate will lead to.

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It must be allowed that it at times becomes an inconvenience, by crossing the views of higher authorities, and thus depriving them of the liberty of action, by the creation of an unalterable situation. But as this spirit of initiative is essential to modern conditions, higher commanders must be prepared to support their subordinates, as nothing will kill initiative in the lower ranks more than the fear of being left in the lurch if they attempt anything without sanction from above. Many examples can be quoted from history where the misplaced initiative on the part of the subordinate has led to disastrous results, as in the Battle of Spicheren. If initiative in the subordinate is apt to lead us into dangerous channels, are we to give it up? No, that cannot be right, for modern developments tend more and more to limit the power of control, and to increase *pro rata* the advantages of individual enterprise. There is a means of preventing the possible ill consequences of initiative, and that is, the uniform training of the faculty of judgment. The whole of Sir John Moore's System was one of developing, and not repressing, intelligence; of making the development of the man contribute to the effective unity of the whole; of enlisting the zeal of the private as much as of the officer. His was the discipline of the good football team, none for himself, each man for his side.

The subordinate must therefore be trained to play for his side, to ask himself whenever the occasion for individual action arrives, not "What personal distinction can I gain from this opportunity?" but "What would my superior officer do if he were here?"—"What orders would he give me? How can I best help him in his absence?". That is the kind of initiative that is required and is essential in the modern army. The spirit of initiative urges independent action. We rightly adhere to the principle that, in the case of an officer who has been guilty of neglect, the excuse that he has received no orders is of no avail. Passive obedience is not sufficient, not even the fulfilment of what was ordered, where an opportunity occurred for doing more.

Conclusion.

Initiative is essentially a British spirit. It does not require much to cultivate it but it does require knowledge and practice to lead it into the right channels. In the first place to have initiative, you must know your job, and know that you know it. You do not get initiative from a man who is not self-reliant. In the second place, you must know and trust your superiors and subordinates, and they must know and trust you. Frederick the Great demanded that each officer should prepare himself for the next higher rank, and thus cultivate the power of independence and spirit of initiative. Initiative is opposed by powerful enemies and these have to be fought: the habit of acting by rote, the fear of responsibility, the habit of the majority of men to allow themselves to be carried by the flow of events instead of acting on their own judgment. These negative forces paralyse all power of action.

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Initiative can easily be driven out of an army, but it is almost impossible to re-establish it when once lost. A sound training of the intelligence and judgment will prevent its loss, and give a spirit of initiative tempered with self-subordination, and with the spirit of playing for the side. Initiative is the independence based on intelligence and judgment which prompts an inferior to promote the ends of his leader.

PRÈCIS OF

REVUE MILITAIRE SUISSE.

By Captain G. de L. Landon, M.C., R.A.

September, 1917.

The Italian Theatre of Operations (continued).

A summary of the results obtained from the successful Italian offensives of May-June 1917 in the Carso and on the Izonzo, and a short description of the Austrian counter-attacks in June. The latter were unsuccessful everywhere except in the extreme South on the sea where they advanced a few kilometres between Flondar and San Giovanni. The author gives great credit to the Italians for their successful advance and considers that they showed themselves the superiors of the Austrians in both attack and defence.

A raid in trench warfare.

Translated from the American Infantry Journal of June 1917. A concise account of a raid carried out by the French for purposes of identification on the Western Front. The objective was a small salient in the German line, the infantry detailed for the attack consisting of 100 men divided into four groups. The artillery supporting the attack consisted of 12 trench mortars of 58 mm. calibre, 6 batteries of 75's, and 3 batteries of 155 mm. howitzers. The trench mortars were divided into two groups of six mortars each and were detailed to make two breaches in the barbed wire. The 75's formed a barrage behind and on the flanks of the salient, the howitzers dealt with hostile batteries and machine-guns.

Two aeroplanes took part, one to direct the fire of the artillery, the other to keep the divisional commander informed of the progress of the operations.

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The artillery preparation commenced at 3.40 p.m. By 4.40 the trench mortars had made the required breaches in the wire and at 5.10 their fire was directed on the front line trench special attention being given to the flanks of the portion of trench to be attacked. They continued firing throughout the operation so as not to reveal the moment of the assault. At 5.20 the barrage fire was lifted to 150 metres beyond the point of penetration and at 5.22 the infantry advanced. At 5.28 three prisoners were brought in and a rocket fired to recall the assaulting infantry. At 5.33 all the infantry had returned and at 5.35 a rocket announced the fact to the artillery. The casualties to the raiding party were nil.

Ammunition expenditure.

Trench mortars	1212	rounds.
75's	6340	„
Howitzers	1690	„

Conclusions drawn.

(a). For the raid to be successful, the detachment detailed to carry it out must be specially trained for a week over ground which is an exact replica of that to be attacked.

(b). A complete liaison between infantry and artillery is of the greatest importance.

(c). In such a short operation it is difficult to clear enemy dug-outs.

(d). The assaulting party should carry gas masks for protection against gas grenades.

(e). The morale of the men is efficiently sustained by the protection afforded them by their own guns, which allows of their penetrating the enemy position and bringing back the required prisoners without loss.

November, 1917.

Characteristics of the Belgian Front.

The first instalment of an article by Commandant Willy Breton, of the Belgian Army, in which he describes the work of the latter during the retreat from Antwerp, the Battle of the Yser, and subsequent stationary warfare.

The individual instruction of the British soldier.

A short note on a pamphlet circulated among the officers of the Swiss Army describing the methods employed in one of our Infantry Training Schools in France. The article is eulogistic in tone, and the writer is particularly impressed with our ideas on the value of drill and the matter of saluting.

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December, 1917.

Characteristics of the Belgian Front.

Continuation of an interesting article by a Belgian Officer, Commandant Willy Breton, on the conditions of the Belgian Front and the various works carried out in its organization for defence. The present article describes the following works.

Concrete shelters, redoubts, and fighting posts, the construction of which has required from 350,000 to 400,000 cubic metres of concrete.

Means of communication—railways, light railways, roads, bridges, and foot-bridges, composing 180 km. of normal guage railway, several hundred of light railway, hundreds of bridges and thousands of foot-bridges. This work has been greatly added to by the inundations, many kilometres of track being obliged to be raised above the floods and one bridge 800 metres in length being necessary.

Owing to the systematic destruction by the enemy of all villages and buildings within range no cover existed for the troops in reserve and resting. It has therefore been necessary to scatter hutments for 100,000 men and 15,000 horses all over the zone behind the front line, besides accommodation for the wounded and the various other services necessary to the Army.

Artificial screens. As most of the ground can be overlooked by the enemy it has been necessary to erect successive line of artificial screens of canvas, branches, and rushes across the entire region. To the eye of the German observer these screens are superimposed one upon the other and effectually conceal the areas so covered. The upkeep and repair of these screens absorbs a very large amount of labour.

Supply of fresh water. As all the existing wells were fouled by the inundations all drinking water had to be brought up from far in rear. As soon as circumstances permitted fresh wells were sunk, it being generally necessary to go down to 125 metres and often deeper still.

Telephonic communications. The extent of these may be gathered from the fact that the total length of cable employed is 21,950 kilometres or more than half the length of the equator. Of this 6,600 kilometres is buried or submerged, the remainder being air-line.

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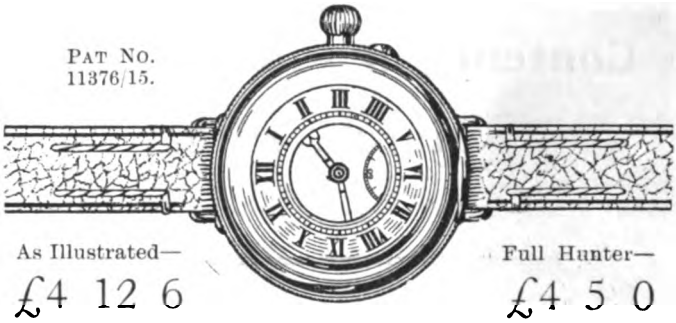

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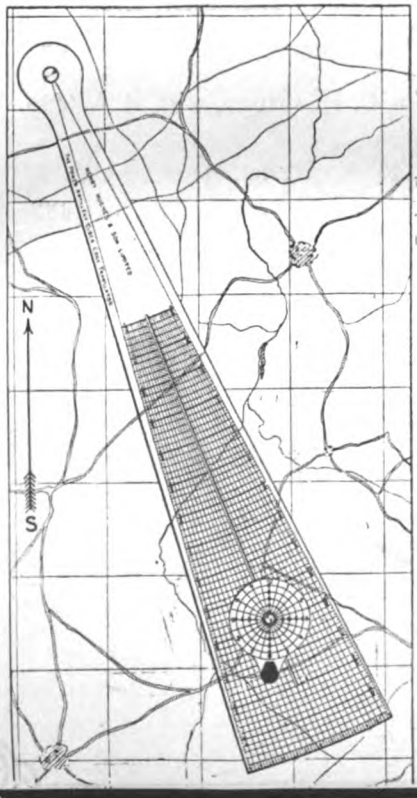

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ATMOSPHERIC NITROGEN AND MODERN EXPLOSIVES.

By Capt. O. F. G. Hogg, R.A.

NITROGEN, although chemically inert without colour taste or smell, non-inflammable and insupportable of combustion, is of the greatest importance in the manufacture of explosives used in modern warfare, and incidentally also to the support of plant and animal life.

After the experience of the last three years this statement may possibly strike the untutored mind as an amazing contradiction. Fabrication of explosives and the support of animal and human life hardly appear to form an harmonic at present. But on looking deeper we readily appreciate why nitrogen is so important in both these respects. Its well of activity depends solely on its atomic inertia, which like all paradoxes veils a great truth.

After all physical energy is nothing more than a constant series of small explosions, a ceaseless anabolism and kalobolism of complicated nitrogenous compounds composing the cellular tissues of animate bodies. Protoplasm consisting in its essentials of proteids is built up of unstable molecular compounds formed from amino-acids, of which nitrogen forms a so-called "loose link". The reason why nitrogen is more often found free in nature than in combination with other elements i.e. why it is chemically inactive, is because compounds of which it forms a part are usually so unstable that for any slight readjustment of external forces disintegration rapidly follows their formation. Hence an ideal agent for incorporation in explosives and vital phenomena.

Nitrogen forms 80 per cent by volume of the atmosphere and is mixed with oxygen and small traces of carbon dioxide, ammonia, argon, neon, etc.; but until quite recent times it has been impossible to combine it in its atmospheric form with other elements to form compounds useful in chemical industries and fertilization. This now, however, has become a matter of world-wide importance and in no branch of chemical engineering or industry is there such feverish activity in prosecuting experiments with the different processes lately brought into existence, which in some cases are only now in the nature of laboratory experiments and have got yet to prove their worth in the commercial arena.

To assign a cause for this anxiety on the part of nations to harness a gas which is in such abundance everywhere and which surrounds the earth to an estimated height of 40 miles, is not a task of a great difficulty; for it is one of the elements of Nitric Acid, itself the principal reagent which with Toluol, Phenol, cellulose and glycerine are converted into the modern explosives T.N.T., lyddite, guncotton, and nitro-glycerine. Especially as the only other forms

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in which nitrogen is found in any quantity in Nature are Chili saltpetre or nitre and ammonia. Of the latter which is recovered as a bye-product in the manufacture of coal gas, producer gas, and at coke-oven plants, and is therefore only obtainable in limited amounts, more will be said hereafter. It may be stated that the former Chili saltpetre has been the chief source from which all the nitric acid necessary for the production of explosives up to within the last few years has been manufactured; it is also used in large quantities in its natural state as a fertilizer in agriculture.

Sodium nitrate occurs in enormous quantities in the valleys of the Tarapaca and Tacoma along the coasts of Chile and Peru. These vast beds cover areas of many square miles, and "caliche" which is the local name for the rock-like mass in which the nitre is formed contains from 10 to 80 per cent of nitrate varying on the depth and locality, large quantities of common rock salt and other sodium compounds. It is worked up by boiling and filtration and rough nitre containing 90 to 95 per cent of sodium nitrate is shipped to Europe for use either directly as a manure, or indirectly for the manufacture of nitric acid. The export to all countries has grown from 1,400,000 tons in 1900 to 2,542,000 tons in 1912. The distribution to the various Powers in 1912 was as follows:—

United Kingdom	5·6%
Germany	33·3%
Holland	5·9%
Austria-Hungary	·25%
Sweden	·15%
France	14·3%
Belgium	12·2%
Italy	2%
Spain & Portugal	·5%
U.S.A.	22·2%
Japan and other countries	3·6%

War has, however, altered all the old principles governing imports and exports, and faced with the submarine menace and shortage of merchant tonnage, the world has found it imperative to discover a substitute which has not to run the risk of being conveyed thousands of miles over the sea in vain and yet can be made in very large quantities. Even in pre-war days it had become apparent that the adoption of some other means were necessary to insure the supply of this valuable nitrogen in a marketable form, for the beds of Caliche are not expected to last much beyond the year 1940, although some scientists advance that date by another 50 years.

It will thus be seen that if atmospheric nitrogen can be utilized to form nitric acid with or without the formation of ammonia as an intermediate stage, a great advance will have been made towards the problem of maintaining an adequate supply of those nitrogenous substances, so necessary for the arts of peace and war.

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It is proposed to give a short description of how these difficulties have been overcome, and what processes have been adopted by the pioneers in this filching of Nature's secrets. It is also hoped that a diagrammatic tree in Table I. showing the progress of the gas throughout the various stages from its origin to its final state of chemical combination in nitric acid, may prove an aid in rendering the text more lucid.

Production of Nitric Acid.

The establishment on a very large scale during the past 20 years of processes for nitrogen fixation is one of the most striking electro-chemical developments of modern times. At present there are three different methods in commercial operation for this harnessing of atmospheric nitrogen in the service of man.

(i). The first method consists in oxidising nitrogen to nitric oxide in the electric arc and absorbing the oxide in water to form nitric acid.

(ii). The second method consists in heating calcium carbide in pure dry nitrogen whereby the latter is absorbed forming calcium cyanamide. This process is carried on in Norway, Sweden, France, Italy, Germany, and the United States of America.

(iii). The third and most recent method, introduced by Haber in Germany is the direct synthesis of ammonia from its constituents nitrogen and hydrogen, the resultant gas being then oxidised to nitric acid.

Outside the realm of business enterprise, there is yet a fourth method at present in its infancy at the laboratory stage. But it has proved highly successful as such and shows great promise. It is called the cyanide process and is somewhat similar to the cyanamide method described above.

Before proceeding with a description of these modern methods, it may be well to give a brief outline of the older sodium nitrate process for the production of nitric acid, a process which like that of the electric arc does not involve the presence of ammonia as an intermediate stage.

This process has several methods, but in the main they are very similar and a general outline only will be given embodying the principal features governing the chief operations.

It depends upon the simple fact expressed by the following equation:—

$$NaNO_3 + H_2SO_4 = NaHSO_4 + HNO_3$$

that sodium nitrate when heated with sulphuric acid gives off fumes of nitric acid leaving a solid residue known commercially as "nitre cake".

In the factory large iron pots—called nitre-pots—capable of holding two tons of Chili-saltpetre are built up over furnaces. To make the correct reaction 4500lbs. of sulphuric acid sp. gr. 1·84 are added to the two tons of nitre and the whole heated for twenty hours. When used in this initial operation the iron pots are named "nitre-retorts". The yield is about 2500lb. of nitric acid sp. gr. 1·503 and

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100lbs of weaker acid sp. gr. 1·4. The latter is again heated with sulphuric acid in the proportion of 76:71 by weight of acids in similar iron cauldrons known in the second operation as "nitre-stills". If the ratio is calculated in units of a hundred pounds then 3500lbs. of strong nitric will result along with another 100lbs. of weak. The weak is utilized again for concentration and thus forms an endless process.

From the top of all these pots runs an earthenware pipe in a downward direction, which bifurcates at a point below that at which the nitric acid condenses. The main branch is the acid pipe which again forks into two, each limb being controlled by a stop-cock; the other is the fume conduit by which the oxides of nitrogen are led away to the condensing towers. One limb of the acid pipe leads through a cooling coil immersed in water to the nitric acid storage tanks, and it is through this conduit that the strong acid of sp. gr 1·503 flows. The other leads direct to the weak nitric tanks where acid below sp. gr. 1·503 is stored pending its return into the "still' for concentration purposes.

The idea of the two stop-cocks is obvious and needs no comment. It is to regulate the flow of the acid according to strength, samples being drawn off and tested from time to time to insure regularity in this respect.

The fume pipe leads first to cooling coils, not immersed in water but over which cool water incessantly trickles and drips. This is to obviate the difficulty of condensing the free nitrous acid present in the fumes which would be detrimental to the finished product. The fumes are then drawn up a series of towers filled with broken earthenware and down which water is forced under pressure, by means of a partial vacuum. In this manner most of the nitric oxide is absorbed and the water converted into weak nitric acid. After the towers this weak acid flows into the weak acid storage tank whilst the remainder of the reddish gases escape into the atmosphere.

Each retort has an emptying plug at the bottom through which the molten residual mass is allowed to run out into shallow iron pans and solidify. It is then broken up and known as nitre-cake.

Such in short is the sodium nitrate process, simple indeed but one which cannot endure for ever.

Nitrogen Fixation.

(i). *The Arc Process*:—

It has been known since 1797 when Cavendish demonstrated it that electric sparks in air form an oxide of nitrogen which if dissolved in water give rise to nitrous and nitric acids, but it is only within the last 14 or 15 years that the phenomenon has been brought into practical effect by the use of an electric arc. The process is represented by the equation:—

$$N_2 + O_2 = 2NO - 43200 \text{ calories}$$

a fact which shows that the reaction is endothermic and one that requires a very high temperature if any appreciable percentage of the volume of the air is to be converted. Moreover it has been found that nitric oxide is unstable and will decompose unless very suddenly cooled to below a temperature of 1500° C.

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Hence the conditions for practical success are:—

(a). A very high temperature such as 3000° to 10000° C. which can most conveniently be produced by an alternating current of 5000 volts.

(b). An extremely rapid cooling to a temperature of about 1000° C. and furnaces have been constructed with these ends in view.

It will be seen from the foregoing that a very large amount of power is needed and unless this can be produced cheaply the method cannot hope to meet with commercial success. Water has consequently always been employed as the source of energy and in Norway owing to its many waterfalls and mountain streams the industry has been developed to a very considerable extent. The efficiency of the process is however low, 1 Horse-Power per year producing only ¾ ton of nitrate in the same period of time.

Three well-known furnaces have been used on a large scale with considerable technical success. These are

(1). The Birkeland-Eyde Furnace.

(2). The Pauling Furnace.

(3). The Schönherr Furnace.

It is not proposed to describe all these as they all differ in detail, but as a type the last mentioned will be outlined.

The Schönherr furnace shown in Figure I effects the fixation of nitrogen as follows:—

The air after being first heated passes up and down two of the inner tubes and is driven up the central tube in a helical path around the arc. Then it finally goes down the outer brick-lined tube when it contains from 2 to 2·5% nitric oxide and is at a temperature of about 850° C. From the furnace the gases pass through a stream boiler in which they are cooled to 200° C. and further through a cooling chamber where their temperature is reduced to 50° C. They then enter oxidisation chambers with acid proof lining where the reaction expressed by

$$2NO + O_2 = 2NO_2$$

takes place. However some 25% of the nitric oxide (NO) remains unoxidised and the air and mixed gases pass into the absorption towers where they meet a stream of water, becoming weak nitric and nitrous acids. By pumping the water from the last tower to the first again back through the intermediate towers a weak acid solution containing 50% HNO_3 is attained.

For shipment this is converted either into the nitrate of lime, soda or ammonia.

(ii). *The Cyanamide Process.*

In this process about 5 times the amount of combined nitrogen is produced from a definite horse-power installation than is the case with the arc process just described.

This method involves

(a). The production of calcium carbide in a large electric furnace from lime and coke or anthracite coal.

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(b). The fine pulverization of this calcium carbide out of contact with air.

(c). The raising of a portion to a red heat in order to start the absorption of nitrogen to form cyanamide ($CaCN_2$).

(d). Grinding up this cyanamide or giving it some special treatment for removing acetylene gas in order to avoid possible explosions later.

(e). Incorporating this powdered cyanamide with lime and carbonate of soda, and treating the mixture with steam in large autoclaves to convert the nitrogen into ammonia.

The above reactions are summarised in the following equations:

$CaO + C = CaC_2 + CO$
Lime + Coke = Calcium Carbide + Carbon monoxide.
$CaC_2 + N_2 = CaCN_2 + C$
Carbide + Nitrogen = Cyanamide + Charcoal
$CaC_2 + 3H_2O = 2NH_3 + CaCO_3$
Cyanamide + steam = ammonia + carbonate of lime.

The second of these is reversible and exothermic and therefore the temperature must not be allowed to rise above about 1400° C.; the action proceding of its own accord when once started.

The nitrogen may be obtained by liquifying the atmosphere and separating that constituent by fractional distillation, as carried out in the Linde process.

The value of Calcium cyanamide—or Nitrolim as it is also called—apart from its present day use can be seen by a glance at the table subjoining.

This process has become very popular in all parts of the world, including Norway where 200,000 H.P. derived from water-falls are devoted to this purpose. Germany, Italy, Austria, Switzerland, U.S.A., India, and Japan also have Nitrolim plants.

The world's output in 1913 was estimated at 223,000 tons.

(iii). *Synthetic Ammonia*:

(A) Haber's process.

In this method nitrogen obtained from the air by the Linde process directly combines with hydrogen to form ammonia, heat being evolved during the reaction according to the equation

$$N_2 + 3H_2 = 2NH_3 + 11900 \text{ calories}$$

By subjecting the gases to pressure the formation of ammonia proceeds more favourably, and Haber employed in his experimental plant a pressure of 200 atmospheres and a temperature of 500° to 700° C. By passing the gases over a catalyst with this temperature and pressure he succeeded in obtaining a combination forming from 3 to 12% of ammonia.

A diagram of this experimental plant is shown in Figure II.

The ammonia is separated from the uncombined gases by liquefaction at a temperature of about—70° C.; the freezing mixture used being made of solid carbonic acid gas and ether; the uncombined gases then circulate through the apparatus again when another corresponding 3 or 4% of ammonia is formed. The process is thus continuous and a fresh supply of gas 1 part of nitrogen to 3 parts of

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hydrogen is pumped into the system through an inlet valve to counteract the liquefied and extracted ammonia.

The power required is small, but a staff of experts is required to attend to the plant.

Several large factories employing the process are believed to have been erected since the outbreak of war, and it has been stated that one of them was destroyed during the recent big explosion in Germany. Details of the working of these factories have not been published, nor is anything known of the actual catalysers in use or of the working temperature and pressures. Several metals including tungsten, uranium, and osmium were found by Haber to be suitable in this respect.

(B) General Chemical Company U.S.A. process.

This is similar to the Haber process but lower pressures are employed, whereby the plant is simplified and does not require such highly trained men to look after it. It has been in successful operation on a large experimental scale, but nothing has been published of its details. The American Government are however taking up the manufacture of ammonia by this process and probably now have a large plant in operation.

It is said that a factory yielding annually 2700 tons of ammonia equivalent to 8700 tons of 96% nitric acid, assuming 85% recovery would require about 500 H.P.

The above are just outlines of the three commercial methods for the fixation of nitrogen, the fourth which was mentioned was however stated to be still in a laboratory stage. It was alluded to as the Cyanide process, and its procedure is as follows:—

The cyanide is produced by heating sodium carbonate and ground coke or coal in any form with finely divided iron to a state of redness and passing nitrogen through the mass. Nitrogen then becomes fixed as sodium cyanide. When the latter is once formed it can very readily be converted into ammonia as is the case with cyanamide, but has the advantage that in the conversion sodium carbonate can be recovered and used over again. The iron may also be repeatedly utilized in this process. Thus, although only in the nursery stage there are great prospects for the future of this method.

By-Product Ammonia.

As mentioned before sodium nitrate and ammonia from gas-works and coke oven plants were until quite recently the two chief sources of nitric acid production. The ammonia obtained from the distillation of coal is derived from the nitrogen and hydrogen contained in it, the percentage of nitrogen being about 1·7 and of hydrogen about 5·0. After the distillation of coal the nitrogen is disposed of as follows:—

Nitrogen in Ammonia	14·5%
Nitrogen in Cyanogen	1·56%
Nitrogen in coal gas and in tar...	35·26%
Nitrogen remaining in the coke	48·68%
	100·00%

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When however coal undergoes destructive distillation in a current of superheated steam as in the case of certain Producer gas plants, about 3 times the usual amount of ammonia is recovered.

The ammonia besides being converted into nitric acid can be treated with sulphuric acid; this forms ammonium sulphate which as such is invaluable as a fertilizer. In fact in pre-war days this was the chief use found for ammonia and in 1914 the total output of this salt in the U.K. was 421,000 tons.

In all these processes outlined above, it will be seen that with the exception of the old Chili saltpetre and the electric arc methods, the intermediate stage of the production of ammonia is a necessary step in the final manufacture of nitric acid. So far we have merely been considering the various ways of obtaining ammonia from atmospheric nitrogen; we must now complete the story and dwell on the second stage, namely its oxidisation to nitric acid. Table I will render this quite clear.

Oxidisation of Ammonia to Nitric Acid.

In 1830 ammonia was first oxidised by using platinum as a catalyst, but owing to the cost of ammonia the method was not pursued. From the year 1900 and onwards, however, great strides have been made in the process; and with the cheap production of synthetic ammonia it is becoming the most important commercial method of producing nitric acid.

Under the influence of a catalytic agent ammonia can be oxidised by air to form nitric acid and water, thus:—

$$NH_3 + 2O_2 = HNO_3 + H_2O$$

Unless certain conditions are maintained however, the oxidisation may be incomplete and only nitrogen produced. By using smooth platinum as a catalyst the first reaction, i.e. the formation of HNO_3 takes place, but the action is very slow; by using finely divided platinum the reaction is accelerated, but more of the second i.e. the production of nitrogen occurs. But by a judicious use of both smooth and finely divided platinum the action can be made to take place rapidly without any great liberation of nitrogen. Thus the secret lies in the proper mixture of the two kinds of platinum; and the rate of flow of the ammonia. This correct blending of catalysers, and the dimensions of the tube through which the gas passes all form the subjects of most of the patented processes in existence. Platinum is not the sole catalyst for this purpose, and others such as a mitxure of ceria and thoria and of oxides of iron and copper have received attention from chemists.

Works now exist for the oxidisation of ammonia in several parts of the United Kingdom.

The actual details of these plants in commercial use are kept secret, but the following notes indicate the general line of action.

The Frank Caro process involves passing mixtures of ammonia and air through electrically heated platinum nets of 80 to 100 meshe. The platinum is heated to a dull red-heat and serves as a catalytic agent under whose influence the ammonia instead of burning to nitrogen and water, causes the nitrogen to form nitric oxide.

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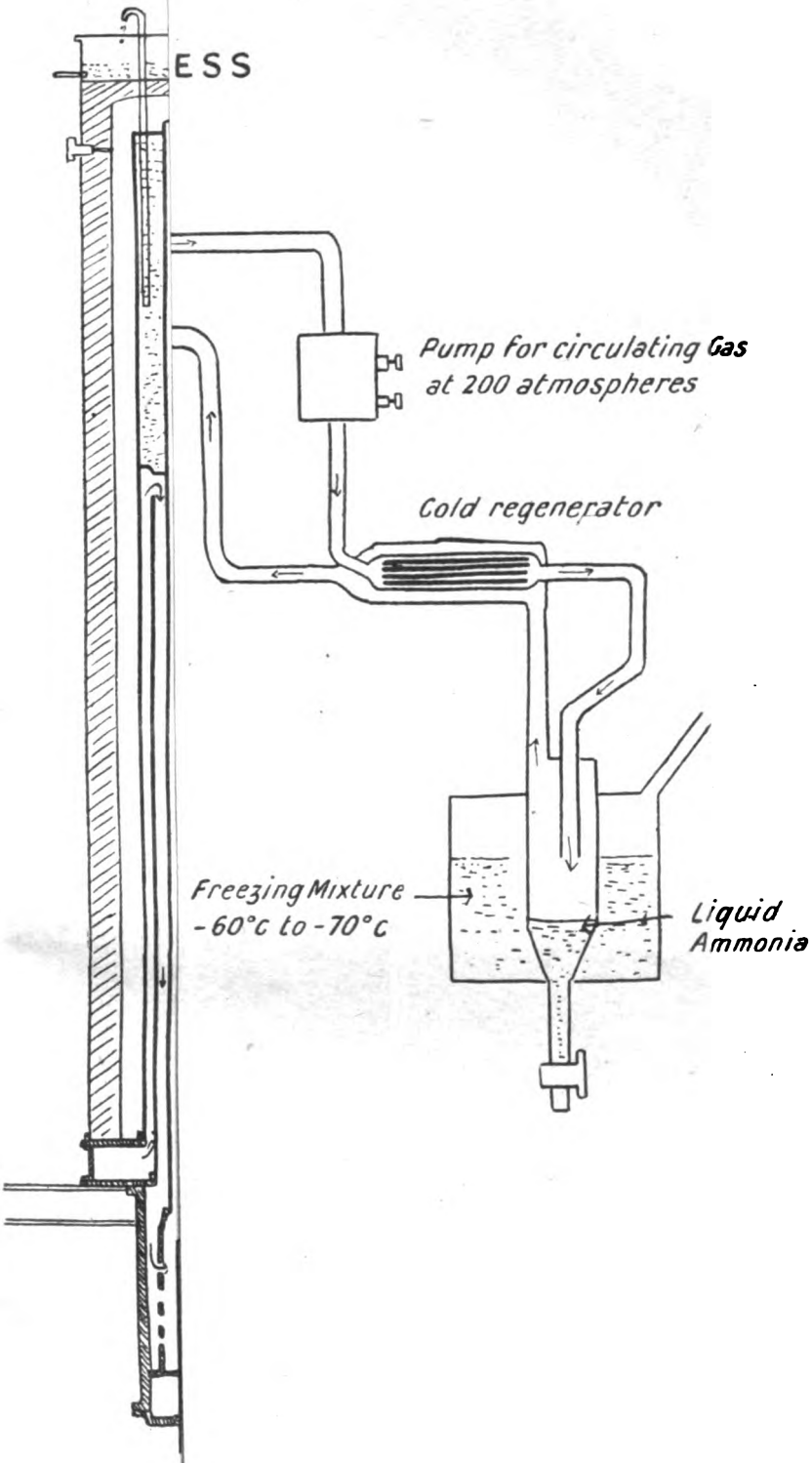

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The Landis process passes the gas downwards through the net instead of upwards, and instead of heating cools the mixture of ammonia and air before they are allowed to come in contact with the net.

The Ostwald-Barton process is now installed in France, being much the same as that originally invented by Ostwald in 1902. It differs in the catalyst which although it consists of metallic platinum is not of the usual pattern. The details are carefully guarded but it is known to have a very small cross section and is placed at the end of a 60 mm tube, so that the products of combustion passing through the tube heat the mixed ammonia and air by radiation, as they approach the platinum. The reaction when once started continues without external heat and without interruption for weeks. It is simply necessary to force the mixture of gases through the catalyser by means of a blower.

By the oxidisation of ammonia nitric oxide gases of a much stronger percentage are obtained than those produced by the arc process. Accordingly much less tower space is needed for their absorption and much more powerful acids can be directly made by concentration. Although in the arc process it is necessary to concentrate 30 to 35% nitric acid to strong acid, in this process an acid of 50% strength can easily be obtained direct from the towers.

Explosives derived from Nitric Acid.

Having by these processes just described arrived at a cheap and steady way of providing nitric acid, we reach the point where the arts of peace and war branch apart. Manures and explosives both spring from this same source. Ammonium nitrate is largely used as a fertilizer and will serve as a type. It is common knowledge that the agricultural and horticultural properties of the soil are greatly enhanced by the careful and judicious system of manuring, and our adequate food supply, i.e. the production of the maximum crop possible per acre depends upon such a course. The enrichment of the ground and the nutrition of the crops in question takes place by means of the nitrifying and de-nitrifying bacteria in the soil, and these with decaying vegetable and animal matter make what is known as the "nitrogen cycle". However, it is not proposed to pursue the question farther here, fascinating though its study is, nor is it intended to dwell for any length of time on explosives. For the article is not so much concerned with their manufacture (which information can be largely gleaned from text-books) but rather with the process made in the earlier stages of their essential reagent.

A glance at Table II will clearly show the importance of nitric acid in this respect, and why it is so necessary to produce it as cheaply and as quickly as possible at the present time.

The principal substances which form essential explosives with nitric acid are Cotton, glycerine, benzol, toluol, aniline and carbolic acid. With the exception of the first two mentioned they are all derivative of coal tar, and are obtained during the distillation of coal as a bye-product in the manufacture of coal gas for illuminative purposes. When these are nitrated to the necessary pitch we get

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(1). Nitro-cellulose or guncotton (probably a tri-nitrate).
(2). Nitroglycerine (a tri-nitrate).
(3). Nitro-benzine (either mono, di, or tri).
(4). Trinitro-toluol or T.N.T. or Trotyl.
(5). Tetryl.
(6). Trinitro-phenol or lyddite.

(1). May be used by itself in a colloidal form, or it may be mixed in various proportions with (2) and some lubricant to act as a propellant. The first class are known as Nitro-cellulose and the second as nitro glycerine powders. Cordite belongs to the latter category.

(2). Mixed with keiselguhr forms dynamite and is usually the nucleus of most blasting powders.

(3) is incorporated in certain high explosives.

(4) and (6) are used for filling shells and bombs whilst (5) is used for filling fuzes and exploders.

After this very brief outline we will leave this portion of the subject and "revenons á nos moutons" in order to see the

Progress in the U.K., U.S.A., and Germany.

It must be acknowledged that in recognising the value of atmospheric nitrogen for explosives and fertilizers Germany was first in the field; and long before the war had mapped out a programme for supplying the world's markets with chemical manures. These latter have to a great extent given place for the time being to explosive manufacture; but owing in part measure to the unrestricted use of the submarine in warfare, they will now find almost every country fully equipped with an efficient plant for manufacturing fertilizers in quantity not only sufficient to supply their own needs but in many cases to export to others. The way of transgressors is hard, and Germany by her ruthlessness and defiance of all human creeds of honour has forged a sickle which after the war will cut at the very heart of one of her greatest commercial and economic enterprises.

In this fact and in the liberal use of these scientific manures in the future may be found the true solution to the problem of world food shortage, a rock in the sea of life towards which the civilised peoples of this globe seem drifting.

During the war the command of the seas has hitherto enabled Great Britain to rely almost entirely upon importation for the whole of our nitre requirements. The Central Powers on the contrary being cut off from the very start from most of their external supplies were compelled to fall back on their internal sources, with the result that the nitrogen fixation processes partially established before the war have developed to an enormous extent. Germany has thus a great incentive to lead in this field. However, what has been accomplished in Germany has thanks to the submarine in a great measure begun to be a "fait accompli" in the United States and Great Britain. It is interesting in this respect to note that reports have recently been published in both countries giving particulars of the research work carried out, and of the recommendations submitted for the setting up of chemical factories of this description on a large commercial basis.

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In the United States, the recommendations of Dr. Charles L. Parsons, Chief Chemist of the Bureau of Mines, in April 1917 were:

(1). That $3,500,000 should be voted to build an initial plant producing 60,000 lbs. of ammonia per day by the synthetic ammonia process as offered by the General Chemical Company.

(2). That the construction of this initial plant should be commenced at once at a spot to be selected by the War Department in South West Virginia or in adjoining territory in West Virginia. The locality to be reasonably near to the sulphur, sulphuric acid, and coal supplies of that region. The plant should be erected near a good water supply having land available in the immediate vicinity for the later laying down of an ammonia oxidisation and nitric acid concentration plant. It should be so situate that a powder factory may be later constructed close by if deemed necessary.

(3). That a sum not exceeding $200,000 should be set aside for experimentation on a large scale of the cyanide process.

(4). That the research work proposed in sub-head 3 should be conducted at Saltville, Pa, where nitrogen soda and coal are available, and where the present plant of the Nitrogen Products Company may be studied and utilized.

And he appends the following table of costs obtained from the books of many companies. Data per ton of nitrogen:—

PROCESS.	ARC.	CYANAMIDE.	HABER.	GEN. CHEM. Co.
Product	35% HNO_3	NH_3	NH_3	NH_3
Power required	10·5	2·2	0·2	0·2
Investment ... $	1410	440	340	300
Operating costs ... $	170	150	119	97
Product	96% HNO_3	96% HNO_3	96% HNO_3	96% HNO_3
Power required	10·8	2·3	0·3	0·3
Investment ... $	1550	670	570	530
Operating costs ... $	220	270	239	217

Comparing notes from the above we notice that to produce concentrated nitric acid which is the object of the fixation of nitrogen the costs of the different processes are proportionately as follows:—

Arc	3350	2·92
Cyanamide	1530	1·33
	OR	
Haber	1268	1·08
Gen. Chem. Co.	1144	1

In England an interim report of the Committee on Nitrogen Products appointed by the Ministry of Munitions in June 1916 was published in February 1917. The substance of the recommendations was as follows:—

(i). By-product ammonia—The importance of increasing the output of by-product ammonia for munitions and agriculture was pointed out. Steps were indicated whereby an increase could be obtained for existing gas works and coke oven plants. It was also

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recommended that action should be taken to avoid the loss of ammonia known to be occurring in certain districts.

(ii). Ammonia oxidisation Process—The erection at the earliest possible moment of plants capable of producing in the aggregate at least 10,000 tons of nitric acid per annum from gas works or coke oven ammonia was recommended.

(iii). Cyanamide process—The construction of a factory having an annual output of approximately 50,000 tons of cyanamide was recommended, the cyanamide to be utilized for agriculture and for the production of ammonia.

(iv). Synthetic Ammonia process. The erection of a full sized trial unit plant was recommended.

In regard to (ii) above it may be mentioned that several firms have already introduced ammonia oxidisation plants to take the place of nitre-pots used in the manufacture of sulphuric acid by the leaden-chamber process. This has economised in the use of Chile saltpetre and thus effects a saving of overseas freight.

In regard to (iv). This process has been so largely experimented upon in the States and has been brought to such a pitch of commercial success by the General Chemical Company, moreover it does not require a large amount of power for its successful overation, that it would seem to be the scheme indicative of the best chance of success in this country from the economic point of view. In this direction the report says "A considerable amount of work has been carried out in connection with the synthesis of ammonia, including a detailed investigation of the whole of the conditions governing the process, and of the efficiency and life of numerous catalysts.

These studies led to the devising of a method of working whereby the output of ammonia per unit of catalyst space has been increased to a figure which as far as is known exceeds anything hitherto attained. The design and erection of a semi-technical unit apparatus embodying a number of novel features with the necessary pumps, circulation, gasholders, etc. were undertaken. It is expected that the operation of this unit which is now at work will enable the remaining problems as to the chemical engineering details involved in the design of the full-sized trial unit authorized, to be definitely settled".

Thus in all countries now we see that the problem of the fixiation of atmospheric nitrogen is being seriously studied, and spurred on by the war theory upon which the human mind likes to dally is giving way to practice. No longer will the vast mass of billions of tons of nitrogen remain inert and quiescent in our atmosphere, its days of working out its destiny in its own quiet way are over, henceforth it must come out into the open. Then man guiding with will and intelligence the forces of Nature will see the earth when her present death struggle is over again bring forth a hundredfold.

"In conclusion I wish to express my gratitude and thanks to Mr. Bennett Powell, A.M.I.C.E., whose notes have been invaluable to me in preparing this article and with whose co-operation it has been written".

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TABLE I.

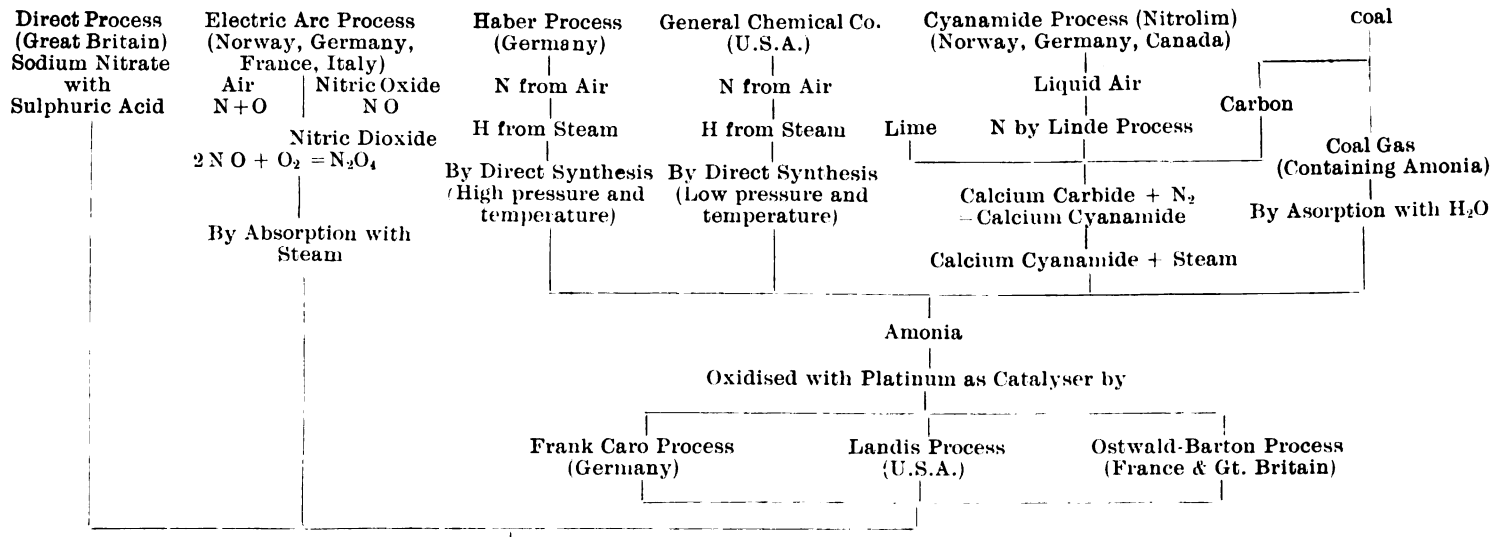
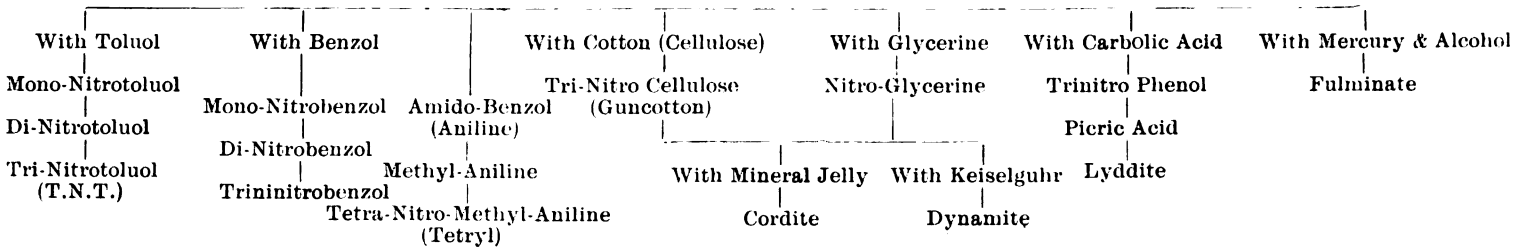


TABLE II.

NITRIC ACID.



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A METHOD OF ALLOWING FOR THE SIDE-SLIP OF A GUN IN A GUN-PIT.

By Major A. H. Burne, D.S.O., R.H.A.

UNLESS the platform is perfectly level, and the gun perfectly concentric with the trail support, i.e. the spade tangential to the curve of the trail support, and the traverse at zero, the gun is very likely to "side-slip" when it is fired.

It then becomes necessary unless the near aiming post is exactly half way between the far one and the gun to adopt one of the following methods:—

(1). Cross-lift the gun.

(2). Lay off the aiming posts the amount the gun has side-slipped by means of a cross piece on each aiming post.

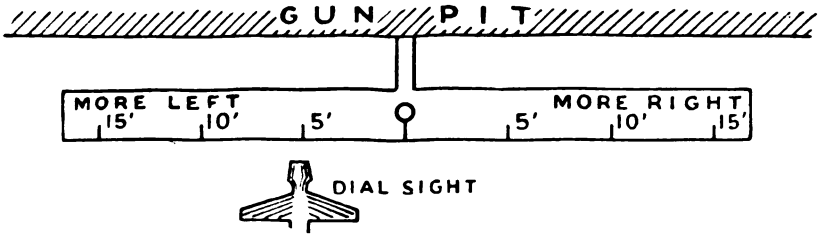
(3). Continue laying on the near aiming post, and put the necessary deflection on the sight.

(4). The use of a parallelo scope.

The following simple device renders the third method, at least worthy of consideration. In practice it has worked well.

Construct a simple deflection scale to read minutes right and left of zero, and fix it to the roof of the gun-pit, so that it is immediately above the dial sight when the latter is in prolongation of the line joining the two aiming posts.

Now, if the gun is traversed to the right, the dial sight will probably move to the left of this line, to some such position as shown in the sketch below.



It is the duty of the No. 1 to watch this deviation scale, and to put on any deflection correction indicated.

In the case above he orders "5′ More Left".

On getting back to zero, of course he takes off this deflection.

The size of the graduations can easily be calculated.

A convenient arrangement is to have the near aiming post 40 yards from the gun; 5′ on the scale is then represented by 2 inches.

The advantages claimed for this method over (2) are:—

(a). Less responsibility placed on the layer. The normal method of laying only is employed, which is a consideration when, as often happens, a battery loses its best layers.

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(b). Any side-slipping in foggy weather or at night is immediately spotted and can be compensated for. Whereas with method No. 2, it is not likely to be spotted, and certainly cannot be compensated for, except by a complicated system of lights on each aiming post.

(c). There is less construction work required: the No. 1 or the Limber gunner can probably make his own scale, and there is less to carry about.

Finally, this is not a theoretical gadget, but a practical device which many batteries have employed with success.

There is also the following objection to (1) which is not universally realised.

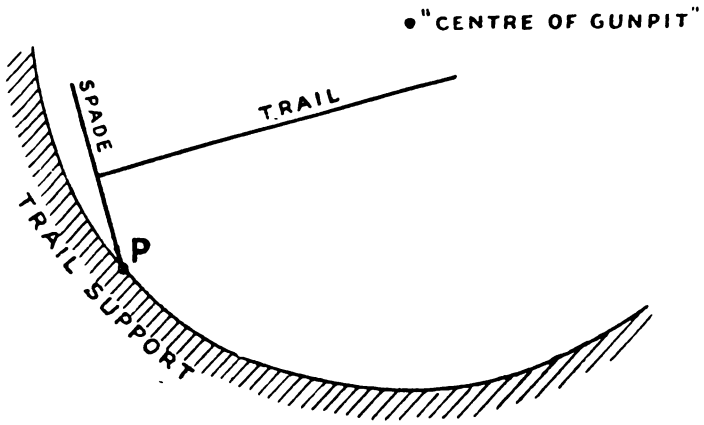
Assuming the trail support to be struck on the circumference of a circle whose centre is under the middle of the axle, (the only sound shape for a trail support): then, when a big switch is made, the gun being revolved about its centre, the dial sight will be moved off the line of the aiming posts.

The gun however will remain in the centre of the gun pit, with its spade at a tangent to the curve of the trail support.

If now the gun is "*cross lifted*" till the dial sight again comes in line with the aiming posts the gun will be out of the centre of gun-pit; and (more important) the spade will not be tangential to the trail support: with the result that bad shooting will probably ensue.

It is mathematically impossible to construct a trail support which will ensure the spade being tangential at all angles of switch, if the dial sight is to remain in the line of the aiming posts.

If this does not appear obvious, let the reader cut out a piece of paper to the scale of a gun, and revolve it slowly about the dial sight: whatever shape and size he selects for his trail support, he will find his spade frequently assuming the position shown below:—



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With the trail in this position the gun, when fired, will tend to revolve around the point P, in other words to side-slip to the left.

(4). The Paralleloscope is devised to get over the difficulty referred to as regards "side-slipping", and a big "switch":—

The writer has never met a really satisfactory one. There are two practical difficulties to be overcome. The first, and most important, is to ensure that the sighting remains absolutely parallel throughout. The least 'play' defeats this; and if there is no play a wooden instrument will not slide properly. The second difficulty is to illuminate the sight satisfactorily in a dark gun-pit.

The first difficulty, it has been suggested, can be overcome by having a mirror in place of a slide: the image of the dial sight in the mirror forms the sight. Probably the problem will eventually be solved on these lines.

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TWO ORDNANCE OFFICE EPISODES.

By Lieut.-Col. H. W. L. Hime, (late) R.A.

WHETHER there is any inborn repulsion between Ordnance officials and men concerned with munitions of war, or whether there is not, is a question for philosophers; but certain it is that they have never loved one another. The complaints occasionally made about the callous treatment they receive now are sometimes accompanied by covert allusions to the good old times, but in this connexion it would be much nearer to the truth to speak of the bad old times; for the neglect a few may have met with in these days is insignificant when compared with their ill-usage under our Sovereigns from Charles I to Queen Anne. This assertion is not intended to cast any reflexion upon these Sovereigns. When anyone is found to have been robbed of his due during Charles II's reign, we are boisterously assured it was the King's own act, the heartless ingratitude of a monarch who squandered his money on female favourites. But the decorous Charles I had no female favourites, and the good Queen Anne had no male ones; yet of the two luckless men to whom I am about to draw attention, the one lived for years under Charles I, and the petition of the other was addressed from gaol to Queen Anne. The truth seems to be that such men were ill-treated by Ordnance officials and their underlings, the Sovereigns being kept in total ignorance of their sufferings.

Colonel James Wemyss was nephew to Colonel Robert Scott, Master Gunner of England, who invented the leather guns used in the Great Rebellion, one of which is to be seen in the Rotunda Museum.[1] On his uncle's death in 1631, Wemyss succeeded to the post of Proof Master, and a Warrant, 26th Feb. 1633, was issued "for carrying such quantity of earth to (his) garden at Vauxhall as should suffice for making a butt to prove Ordnance." But he does not seem to have received the emoluments of his office. On the 9th July, 1637, he presented a petition to Government in which he expresses his "fear of being cast into prison by his creditors". He reminds them that he has advanced £1100 out of his own pocket, and prays that "he be not in a worse estate than the mackannikest (*sic*) man that serves the King, as he has these seven years without receiving a penny".[2] He was appointed Master Gunner of England shortly afterwards, and in a letter to Government, 10th Sep. 1638, he "regrets to say that there are few gunners in the Kingdom at this time who understand the several ranges of ordnance or use of the mortar, which in effect are the special points belonging to a gunner and impossible to attain unto without a great and continued practice". He seems to have joined the Parliamentary forces on the

[1]. These (English) leather guns are not to be confounded with the leather guns used by Gustavus Adolphus in the Thirty Years' War, which were invented by Freiherr M. von Wurmbrandt, an Austrian. See "Who invented the Leather Guns?", "Proceedings R.A.I.," vol. XXV.

[2]. State Papers, Dom. Ser., 1637.

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outbreak of the Great Rebellion, and after he had been taken prisoner at Capredy Bridge, Lord Essex wrote to the Parliament urging that he should be speedily exchanged at any cost:—"a man of his abilities is not to be lost".[1] On the restoration Wemyss was reappointed to his former office; but, notwithstanding his ability, he was suffered to end his days miserably. Shortly before his death he wrote a letter to the King asking for his 'demission', dated 29th Nov 1666, which concludes as follows:—

. . . "he" (i.e. Wemyss himself) "hath nothing from your "Majestie in this his old age to maintain him with, which forceth "him, with your leave and favour, to retire to a private life (how "mean soever), where he shall daily pray for your Majestie's long "and prosperous raigne.

"And remaine your Majestie's
most humble bot ruined servant
James Wemyss."[2]

The petition to Queen Anne which I am about to quote was found in the Chillworth Powder Mills when they were taken over in 1885 by the (present) Chillworth Gun Powder Company. They had the petition printed *verbatim* and I lately received a copy from the Chairman, Captain T. G. Tulloch, late R.A. In the opening paragraph Sir Polycarpus Wharton Bt, who had been "bred in the Art of making Gunpowder," states that in 1677 "he was directed by the Ordnance to take out a lease for 21 Years of the great Powder-works at Chillworth, near Guilford in Surry; at that time in so Ruin'd a Condition, as to require 1500 *l.* to make them serviceable. This was done at Sir Polycarpus's Expence; the Rent, the growing necessary Repairs and incident Charges amounting to 1000 . per Ann. was by his Contract with the Ordnance, Dated January 1. 1677. to be Born by them when not Employ'd by the Crown; and they were not so Employ'd a sixth part of the Term: Notwithstanding which, the said Yearly Charge was defray'd for Ten Years by Sir Polycarpus; who, pressing to be Reimburs'd the same, was over-perswaded to wave that Contract, and in lieu of his Charge, to accept 2000 *l.* by way of Debentur, (of which he never could receive one Penny) and enter into a new Contract for keeping at his own Charge the Works during the Eleven Years then to come: In Consideration whereof he was to Work 1200 Barrels of Powder Yearly above his Proportion with other Powder-makers, as appears by his second Contract with the Ordnance, Dated December 22. 1687.

"That Sir Henry Sheere Surveior General, and Thomas Gardiner Esq; Store-keeper, were by Order of the Lord Dartmouth, Master-General of the Ordnance, Decemb. 17. 1687. appointed to take a previous Survey as well of all other Powder-works in the Kingdom, as of Chillworth-Works; to know thereby what each Work was able to perform, before Sir Polycarpus consented to Execute the said second Contract; whose Report thereon, January 21 following is now in the Office: By which it appears That Sir Polycarpus his Proportion of each 2000 Barrels of Powder to be made, was 1045 Barrels and

[1]. State Papers, D. S. 1644.

[2]. Sir W. Fraser, "Memorials of the family of Wemyss," Edinburgh, 1880, II., 247.

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60 Pounds, and so in proportion to a greater or less Quantity. And whereas the Ordnance did Contract with all the several Powder-makers since the said second Contract with him, to April 27. 1695, inclusive, as by the Ordnance Contract-Books appears, for making 98920 Barrels of Powder, of which Sir Polycarpus, according to his said Proportion, was to have made 51685, He was allotted only 32852. So that without the least Exception against his Powder, or Terms of Working, (which was but equal with other Persons) he was cut short by 18833 Barrels, and the making of so much Powder apportion'd to Foreigners, and others, to keep their Works Employ'd, whilst those of Chillworth stood still upon his Charge. Nor was this all the Injustice he met with: For of the 1200 Barrels, he was to have the advantage of furnishing Yearly above his Proportion, to Recompence him for his Hardships he suffered upon their Breach of his first Contract with them, and the extraordinary Charge he consented to be at during the last Eleven Years (as aforesaid). He was likewise deprived of making 9600 more upon that account; in the whole amounting to 28433 Barrels, which was very near one half of his Just Pretentions."

In the 3rd, 4th and 5th paragraphs he recounts a number of other injustices done him by the Ordnance, incidentally remarking that Chillworth alone could supply 325 barrels of powder weekly "and that was much more than all the other Powder works in the Kingdom together could then furnish, without which it would have been impossible that the Fleet could have been timely supplied with powder."

The 6th, 7th and part of the 8th paragraphs are as follows.

"By all which very hard Measure, Sir Polycarpus from the beginning of his Lease in 1677. to the Expiration in 1698. has been at least 24000 *l.* a Sufferer, altho' he Faithfully and Diligently employ'd all the said time with the utmost hazard of his Person and Fortune in the Crown and Kingdom's Service, and has been (with his Family) utterly Ruin'd thereby.

"Moreover, German Powder being in Esteem for its great Strength the Commissioners for Master of the Ordnance (by Direction of King Charles the Second) ordered the Board to send to Sir Polycarpus, (which accordingly was done by Letter January 18 .1680.) to provide two able Persons to go into Germany, there to inform themselves of the best way of making Strong Powder, and to receive his Highness Prince Rupert's Instructions thereupon. It was however at last agreed by His Majesty and the Prince at Windsor, That Sir Polycarpus should (without any Person's going over) Imitate it here; which upon promis'd Encouragement, he undertook, and brought to such Perfection in one Year, that upon Trial thereof before His Majesty and the Prince, it far exceeded the German Powder in Strength, and could be afforded much Cheaper: Whereupon, by His Majesty's Encouragement, he erected Mills and Works near Windsor (much differing from the Common sort) sufficient to make 40 Barrels of that Powder Weekly, which cost him 2700 *l.* for which Charge, Service and Hazard, he never received any Recompence, nor made any Quantities thereof for the Crown's Service.

"Sir Polycarpus by his Petition to Her Majesty in Council having

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set forth these his Sufferings, obtain'd Her Gracious Reference to his Grace the Duke of Marlborough, Master-General of the Ordnance, November 18. 1703. Who thereupon ordered the Board to Examine and Report the Matter: But no Report could be obtain'd till June 10. 1710. A fatal Delay to him, who was for want of it thrown into Prison, where he yet remains. From thence he sent his Memorial the 14th of June, instancing in three weighty Particulars, where the Report Drawn by Mr. Musgrave was false in Fact. The Lieutenant-General of the Ordnance (in the absence of the Master-General) laid it before the Board to be Examin'd, the 1st of July last: But no Step has been taken therein, because Mr. Musgrave has in his custody the Records of the Office referred to. The producing which would set this Matter in a true Light, and is all the Justice and Favour that Sir Polycarpus Wharton seeks".

Had the Preacher sat down in those times to meditate on "all the oppressions that are done under the sun", he would have had ample food for reflexion.

It is interesting to find in Wharton's petition a complete confirmation of Dryden's verses (quoted in this volume of the Journal, p. 292) on the personal interest taken by Charles II in ammunition. Dryden was taking no poetical license, but was speaking the sober truth. In this trait of his character our King resembled Christian IV of Denmark (1588-1648), "who took a personal and active part in the administration of his Artillery".[1]

We also find traces in the petition of our irrational bias in favour of foreign goods, which has been displayed far more disastrously throughout the last three quarters of a century. We had able manufacturers and a larger supply of gunpowder than we wanted, yet Wharton was "cut short of 18,833 barrels" of the quantity agreed upon, "which was apportioned to foreigners and others". This explains the strange anomaly that while on the one hand we were importing a certain quantity of foreign powder, on the other hand we exporting our own. During the century 1675-1777 we exported over 250 tons of Powder to Sweden alone.[2]

I am unable to explain the allusion to the German powder, Wharton speaks as if there was only one German powder at the beginning of the 18th cent., whereas there were several. Spak speaks of 3 kinds,[3] Decker of 4[4], and I believe there were even a greater number, differing both in composition and size of grain. This I gather from Furtenbach's saying that the 3 powders he describes were "those generally used",[1] and from Mieth's remark quoted by Spak:—"powder manufacture in Germany was at this time (1684) a private industry under no regular control".[5] But whatever the nature of the powder in question, our manufacturers were willing and able to surpass it when an opportunity to do so was given them. It is only too clear that already the evil eye of Germany was beginning to fascinate us.

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1. Kapitain O. Blom, "Kristian den Fjerdes Artilleri," Copenhagen, 1877, p. 15.
2. Kapten F. A. Spak, Öfversigt öfver Artilleriets Uppkomst &c." Stockholm 1878—81, p. 173.
3. "Geschichte des Geschützwesens &c.", Berlin, 1822, p. 26.
4. "Halinitro Pyrbolia," Ulm, 1627, p. 6.
5. p. 174.

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COMMUNICATIONS IN THE FIELD.

By Capt. F. Lankester M.C., R.F.A.

THE communications of an Army in the Field can be compared to the nervous system of the human body. Cavalry, Artillery, Engineers and Infantry are the four main limbs—arms and legs—the Royal Flying Corps the eyes, and the Army Service Corps the stomach. All parts of the human body are controlled by means of the nervous system by the brain. G.H.Q. is the brain of an army and just as countless nerves emanate from the brain to the various parts of the body, so do countless channels of communication diverge from G.H.Q. to the various branches of an army.

However strong and vigorous a man may be, directly his nervous system becomes affected or disarranged he is transformed into a physical wreck. Equally is this true of an Army. However strong its Artillery, Infantry, etc., once they become disconnected from the higher power that controls them, they become practically useless. A Battery or Company no longer in touch with its Brigade or Battalion, may be looked upon as a negligible quantity for forming any schemes for attack or defence.

From the above comparison it may be seen how all-important communication is to an Army. No matter whether he be a General or Private, it is the duty of every soldier to facilitate and help in establishing and maintaining communications.

There appears to be a general theory amongst troops in the Field that "Communications don't affect me, that's the flag wagger's job". Well that is *not* so, it is the duty of everybody to assist in the upkeep of communications. There are many little ways in which everyone can help to do this. For example:—

(1). Even if a telephone wire does knock your hat off, don't break it. Put it up higher if possible.

(2). If you pass a wire that has just been broken by shell fire, join it together. Tie the bare wire together by a reef knot and keep the exposed surface from touching the ground or any other substance by suspending it between two sticks.

(3). When marching along a road or when resting on the march, leave room for dispatch riders to pass without causing them to slow down.

(4). If you are a Gunner and an Infantry "Runner" passes your battery position and asks the direction of his destination, don't point vaguely towards G.H.Q. and say "Over there" help him all you can; show him his quickest route.

(5). If you are an Infantryman, don't always curse the Gunner telephone lines, and don't break them when you are deepening your trench. If you do cut them, don't be surprised one night if your S.O.S. call is not answered.

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(6). Don't Pigeon shoot.

(7). Be concise and short in your telephone messages. Addressing a message to a Unit whose code name is "BARK", don't put "To O.C. BARK". Simply "BARK" is sufficient, it will naturally go to the O.C. or Adjutant. Also two letters and a number is *quite* enough for a "Sender's Number". Numbers like A/BL/537-8 are quite unnecessary for ordinary use. Telephonists are not machines, and each unnecessary letter is a waste of time and energy.

(8). If your telephone is working and you are asked to send a message by another Unit, or even by another branch of the Service, do so at once. Delay or refusal may make the difference between success and defeat.

There are many little points like these, which will occur to anybody if they give the subject a moment's thought, which will make communication and therefore co-operation far easier if attended to. Unfortunately neglect to carry out these points is occurring daily, not through any wilful intention, but merely through thoughtlessness.

Warfare may be divided into two classes:—

(1). Mobile Warfare.

(2). Area (or Trench) Warfare.

In both Classes the main principles of communication are the same:—

(1). Downward to Subordinates.

(2). Laterally to equals.

A Unit is generally responsible for establishing communication to its immediate subordinate; once communication is established the responsibility for maintenance will usually be divided between the two Units.

MOBILE WARFARE.

In Mobile Warfare as few lines of communication as possible should be laid. A Unit can only carry a certain amount of wire and signalling equipment, and if all this is utilised in one position, when a move is ordered, there will not be sufficient for the next.

In the accompanying sketch, the telephone lines laid are only "Downwards to Subordinates"; the lateral lines are shown dotted and are usually visual or dispatch rider routes.

Directly a Unit takes up a position, telephone communication will be established to the subordinate unit and at the same time visual stations will go out to communicate with the "Equal Units" on either flank. Once this flank communication has been established, look-outs only will be posted, in case the main lines break down and an alternative route via the lateral Unit is required. In front of the firing line we have a screen of Cavalry, perhaps three or four miles distant. Any projected attack by the enemy will be known some time previous to its taking place; therefore the net-work of communications established in trench warfare are not required, and would only tend to undue confusion.

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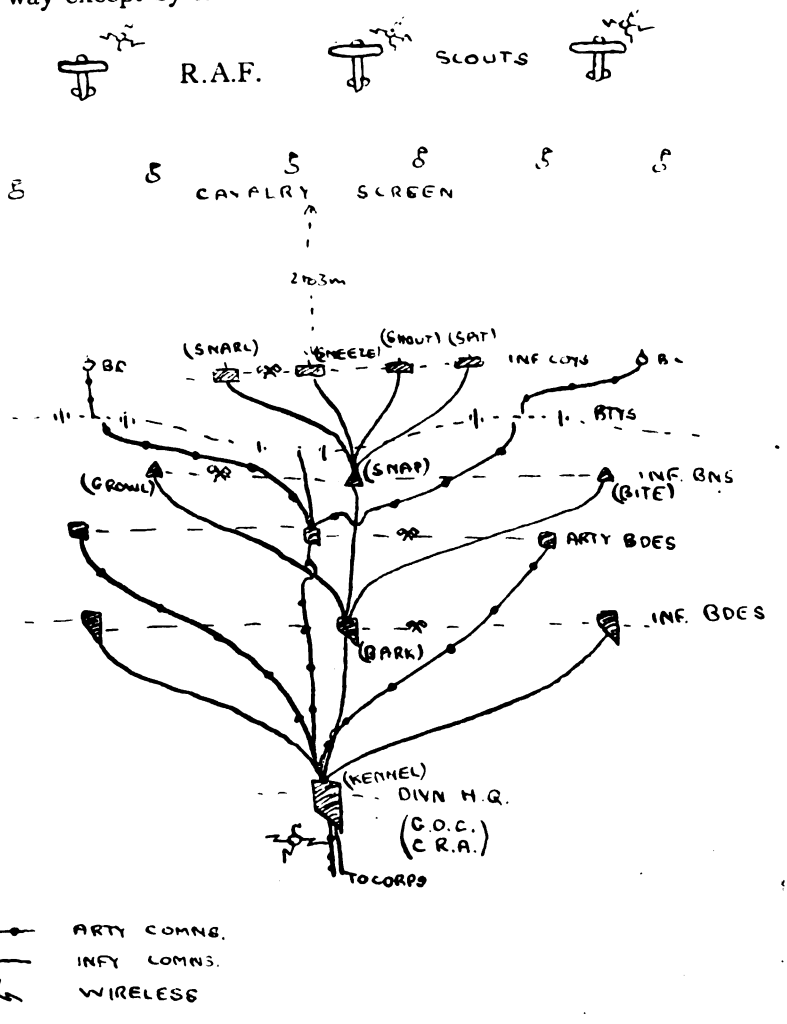
Code names such as "DOG", "BUFFALO", etc. are allotted to every Unit, and no Unit should be addressed or referred to in any other way except by its code name.



Mobile Communications.

AREA (OR TRENCH) WARFARE.

In Area Warfare there is no protecting Cavalry Screen in front of the enemy. The enemy are in some cases only 40 to 50 yards away, and in consequence can develop an attack without warning. Hence the closest communication is required between all Units. In the accompanying sketch each Artillery group is connected to the Infantry Brigade it is supporting and also to the Battalions; each Battery to the Company whose front it covers, and also to the

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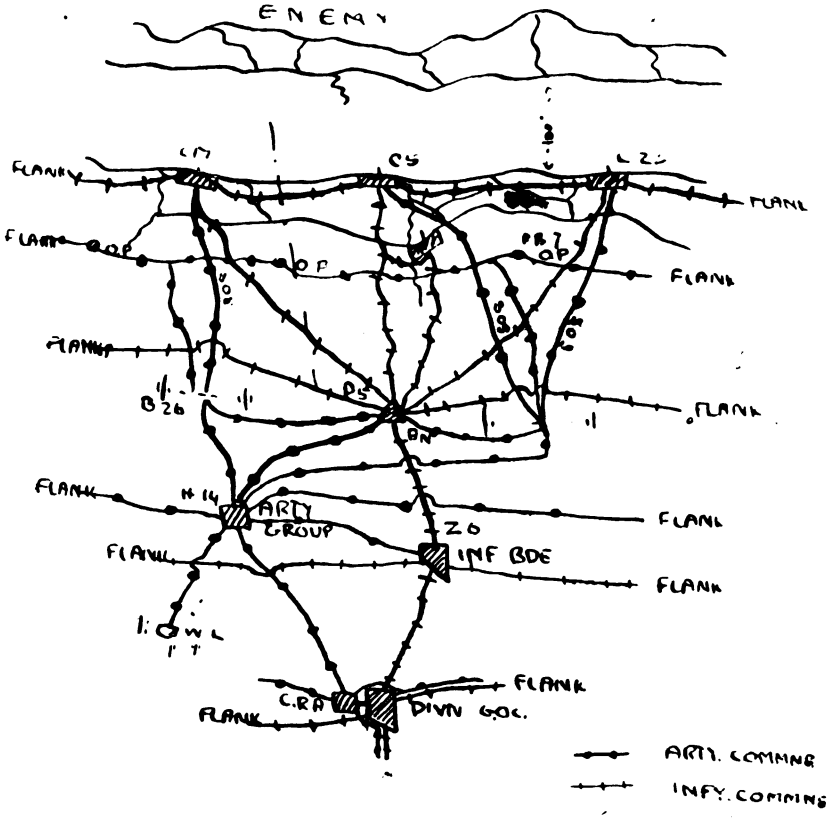
Battalion to which those companies belong. The Brigades, Batteries, Battalions and Companies are all connected laterally.

The direct line from a Company to its supporting Battery is the S.O.S. line and should only be used in case of attack and must be tested throughout the day and night. Every line should be duplicated if possible and visual communication established in case the telephone routes get destroyed by shell fire.

"Position Calls" are allotted to each signal station and remain with that position whatever division is occupying the front. Thus if the enemy overhear signals they cannot tell when new Units are arriving, as they would do if code names or calls were used, e.g.

2nd Essex Regt. (BEETLE—BE) occupies D5 and one of its Companies (WING) occupies C37. For three or four days (WING) calls up (BE) and then 2nd Essex are relieved by the 2nd Northants (DOG—DG) the company then calls up DG. The enemy know at once a relief is taking place and shell the roads and communication trenches. With position calls the company will always be C37 and the Battalion D5 whether (BEETLE) or (DOG) are occupying the line.



Area Communications.

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METHODS OF COMMUNICATION.

(1) *Wireless.* From aeroplanes to the ground; also Trench wireless sets. These are not much used owing to the fact that there is so much "jambing" taking place due to the number of aeroplanes with wireless and that any extra transmitters only add to the confusion.

(2). *Aeroplane.* Maps, sketches, reports, etc. are fixed to the end of long coloured streamers and are dropped over the H.Q. for which they are destined. Anybody who sees an aeroplane message drop should make it his duty to hand it in to the nearest H.Q. in order that valuable time may not be wasted.

(3). *Telephones, Fullerphones, Telegraphs, Vibrators, etc.* Telephones and Fullerphones are used as far as Div. H.Q. Back from Div. to G.H.Q. Telegraph, Wheatstones, etc. are used by the S.S.

(4). *Power Buzzers and Amplifiers.* "Ground Wireless" used over shelled areas during an attack.

(5) *Visual, Lamp, Flag, Heliograph, etc.* used as alternative to telephone lines and over shelled areas.

(6). *Pigeons.* Used by Heavy Artillery and Infantry; and occasionally by R.A.F.

(7). *Kite Balloons.* Visual from attacking troops to Balloon, telephone from Balloon to destination. This is not very satisfactory as there are so many difficulties in keeping up the visual communication.

(8). *Runners.* From first line to nearest working telephone office. Runners, if they have a long distance to go, must be organised in relays.

(9). *Dispatch Riders.* Either mounted on horse or motor bicycles.

(10). *Tanks.* By means of coloured discs and lights, semaphore arms or wireless.

(11). *Rockets.* Subsidiary method. From Infantry to supporting artillery. Also to signify capture of certain objectives.

(12). *Messenger Dogs.* From front line to support.

(13). *Message carrying projectiles.* Rockets, rifle grenades, etc.

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A FEW WORDS ON DISCIPLINE.

By Capt. C. H. Brittan, M.C., R.A.

"A good general, a well-organised system, good instruction and a severe discipline, aided by effective establishments, will always make good troops, independent of the cause for which they fight. At the same time, a love of country, a spirit of enthusiasm, and a sense of national honour, will operate on young soldiers with advantage".—*Napoleon.*

Introduction.

Discipline is made up of a number of very different qualities, and it is only by a proper appreciation of these qualities, and a due knowledge of their action and reaction upon one another, that a successful discipline can be obtained.

It is therefore proposed to deal with the subject under the following headings.—

(a). The meaning of discipline.
(b). Mistaken ideas on discipline.
(c). Foundations of discipline.
(d). Necessity for discipline.
(e). The best methods of producing and maintaining discipline.
(f). Duty of officers.
(g). Conclusions.

Meaning of Discipline.

The idea expressed by the familiar word "discipline" is one which is of an exceedingly complex nature and consequently very hard to define; in fact, if what may be called the leading features are dealt with, and reduced to an exact definition, there are so many side issues that a brief definition cannot fail to be more or less unsatisfactory.

It may, I think, be defined as follows:—

"A constant condition of order in a military body maintained by the submission of the wills of many to the will of one, in the observance of established rules, and by acts indicating respect for constituted authority for the attainment of a common purpose."

The power which enables troops to keep the field and retain their cohesion is discipline.

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Like many other perfectly familiar ideas, it will be found that to different people the word conveys in many ways a different meaning, according to the natural bias of their minds; and further, that a very common error is often made, and the result of discipline is confounded in the mind, and too often in practice, with discipline itself; so that the effect is apt to be confused with the cause. However, in whatever light the subject is viewed, there will be found to be one strong point of resemblance, and that is an idea of conformity to some ideal, expressed or understood.

Mistaken Ideas on Discipline.

There can be no doubt that a strong prejudice exists in the lay mind against military discipline and it has been urged that discipline is only maintained through fear, and that it is incompatible with the self-respect of the free citizen. It is often not understood that discipline is a thing to be proud of; it raises a man above the level of those who have no discipline.

We must therefore carefully distinguish between the rigid discipline of Frederick the Great, and the sense of duty which to-day produces a self-respecting, self-reliant, and at the same time, entirely obedient, soldier. Drill in the days of Frederick the Great was the end, and not as it is to-day, the means to discipline.

"A rigid disciplinarian" is a very familiar phrase, but too often it conveys a very misleading idea, the idea of one who rigidly enforces the penal code. This is without doubt a necessary part of what is wanted, but it is not all, and in the same way as drill, it is only a means, and not an end. The mental and physical aspects are apt to be confused, so that we must bear in mind the objective in view, and consider in a practical manner the existing means we have of promoting the desired end.

Foundations of Discipline.

The foundations of discipline are:—Obedience, Confidence, Loyalty, Patriotism, Religion.

Discipline involves implicit obedience to authority, but the ideal aimed at is not mechanical obedience to dictation. An intelligent appreciation of the circumstances must accompany the perfect submission of the will.

Personal example is all-important, and an officer must set an example to his men on all occasions, since the men instinctively model themselves on him. It is absolutely impossible for an officer to expect obedience from his men when they see him lacking in that quality himself. It is also incumbent upon an officer to set such an example of neatness and punctuality as will enable him to demand such qualities from those under him.

Failures in operation may usually be traced to lack of discipline. Failures are not due to fear, but to the fact that without the sustaining power of discipline many valuable lives are sacrificed, and the effect of individual bravery is reduced. Lack of discipline means

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general inefficiency, and lack of mutual confidence. When an officer cannot trust his subordinates, it means they have not been properly instructed and that the necessary mutual confidence is lacking. As the Duke of Wellington said: "What we want is the habit and spirit of soldiers,—the habit of command on one side, and of obedience on the other; that is, mutual confidence between officers and men."

It must be quite clear that this mutual confidence does not arise because the officer in question is Capt. A. or Lieut. Z., but because he is an officer who has been placed in his position of responsibility by the Government of the Country, which acts for the people as a whole.

As regards Loyalty, Patriotism, and Religion, we have but to look at the discipline of the Japanese Army, which is based on these factors, to be assured of their value as foundations to good discipline. The foundation of the old Turkish discipline was Religion. A glance at the history of any war will teach us the value of Loyalty and Patriotism, both of which have in their turn incited troops to great efforts. The Japanese discipline is not applicable to our English ideas, but at the same time the importance of their principles cannot be over-estimated. The disregard of their faith on the part of the Turkish officers in the last Balkan war materially aided in bringing about their reverses.

Necessity for Discipline.

From the outset of a soldier's training, the vast importance of discipline must be dealt with and be kept before him throughout his service. If this is done, much will be achieved, and the benefits in time of stress will be fully reaped. It is in the battle against odds that this stress will be most keenly felt. In every command the men may be divided as follows: a small percentage of cowards; a certain number of rashly brave men; and the great majority, men of ordinary courage. It is for these men who form the majority that there must be some common impulse, which will steady wavering physical courage, and lay stress on the moral fear of criticism. It is therefore clear that the courage of the average soldier in battle needs a stimulant.

The only stimulant which experience has taught us to be of any avail in such circumstances is that which is produced by discipline. There is of course a time when even discipline fails, and the last resource is the personal influence of the commander. This influence is of immense value, but is given to few. It is not based on respect, but upon personal affection like that shown by Napoleon's troops for their leader, and this personal affection was in itself sufficient to incite them to any effort.

Discipline, which is essential in peace-time, is a vital necessity in war. War means usually but a small amount of actual fighting, and a vast amount of marching, digging, night work, exposure, &c. and trying periods of work without fighting. It is in such periods as these, especially in trench warfare, that it becomes very difficult to maintain discipline. Little result of hard work can be seen, and with

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the excitement of the battle absent, the preservation of discipline calls for constant attention, and it is under such conditions as these that the well-disciplined Army gains the full benefit of its well-ordered state.

Discipline supplies the sustaining power, not as a result of reasoning, but because it is second nature.

Sir Charles Napier said: "No man but the commander can judge what is important and what is not. Soldiers must therefore obey in all things. They may, and do, laugh at foolish orders, but they nevertheless obey,—not because they are blindly obedient, but because they know that to disobey is to break the backbone of their profession".

Discipline produced the capacity to obey orders that brought about the charge of the Light Brigade at Balaclava.

The following weaknesses due to lack of battle discipline are to be expected, and all forms of training must have in view their eradication:—

(i). Sudden disorganization, lack of cohesion and consequent panic.

(ii). Disinclination to close, and bring a trying situation to a successful conclusion.

(iii). Weak fire discipline.

It is only by looking for likely faults that we can hope to prepare ourselves, and by constant attention, reduce the chance of these weaknesses coming out to a minimum.

The lack of discipline on both sides in the American Civil War of 1861-65 is undoubtedly the reason for the length of time the war lasted, and it was not until the North realised how much depended upon this all-important factor, that they were able to bring the war to a successful conclusion.

Again, in the Franco-Prussian War of 1870-71, and in the South African War of 1899-1902, the citizen armies in each case (for the French lost their regular army at Sedan after 6 weeks) had a certain measure of success, but in the end the disciplined army still holding the field, compact and well-provided-for, came out victorious.

Production and Maintenance of Discipline.

In view of all that history teaches us, and from the experience of those able to speak with authority on the subject, it must be allowed that discipline is a condition vital to any military force. How, then, is this discipline best produced and maintained?

Discipline does not come naturally to a man. If left to pick it up haphazard during his service, he never becomes truly disciplined. Men must be taught discipline just as much as they are taught to ride or shoot.

The chief secret in producing initiative and discipline in a unit, lies in uniformly sound training throughout. When men are left to themselves, they will act in the manner to which they have been

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accustomed in their training when under higher command. A uniform system of training, based on sound principles, is the best guarantee of this, and in this way, any subordinate, detached in circumstances when he will have to use his own judgment, can be depended upon by his chief.

The object of every officer should therefore be to secure willing obedience. This is only possible when the officer has both the confidence and respect of his men. He should never try to screen crime; his object should be, to prevent it. Different individuals require different treatment, and it is only by studying his men that an officer can get the required result, and he can then have implicit confidence in their prompt and unhesitating obedience. Discipline means the effacement of the individual, and does more than break the soldier to unhesitating obedience: it teaches him to die, for duty's sake.

The want of the habit of obedience and the reluctance of the independent man to surrender his right of doing things in his own way, combine to produce a weakness, in the disciplinary sense, which is noticeable in all citizen armies and this must be fought.

Apart from the points already touched on, the following will assist in producing and maintaining a good standard of military discipline, if constant attention is paid to them.

(1). The fostering and encouraging of *esprit de-corps* and professional pride.

(2). Strict observance of compliments (e.g. saluting) and all ceremonial details (e.g. steadiness, smartness, and silence on parade).

(3). A thorough knowledge of the disciplinary regulations on the part of all officers.

(4). The administration of discipline, i.e. giving of orders, awarding punishments, etc.

(5). The personality of the officers, their tact, and the knowledge of their work.

(6). Good routine organisation, and training.

Duty of Officers.

Upon the officers devolves the duty of instilling the right sense of discipline and mutual confidence in their men. Officers must insist on the instantaneous obedience of an order, the passing over of any slovenliness in obeying an order is doing the soldier an injury. It is in every soldier's interest to have instinctive instantaneous obedience ingrained into his being and it is the officer's duty to see that this is done. Their personality, tact, knowledge of their work, and pride in their duties and regiment are the instruments which are to their hands, to promote discipline. The safety or ruin of the nation may be said to lie in their hands.

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It may seem that the responsibility of the officer is unduly harped upon, but if it is, it is because I am convinced that the question of discipline is practically in his hands, and capable of satisfactory solution, if faced in the proper spirit, and never lost sight of.

The work that one officer alone can do in this direction is unbounded and once achieved the results are everlasting.

Good discipline in a unit may often be traced to the efforts of an officer who is long since dead, but the fruits of his labour remain. It must not, however, be thought that the duty devolves upon anyone in particular in this direction, but upon every officer of His Majesty's Army.

With reference to this point, General Lee, the famous Virginian leader in the American Civil war, said:—

"Impress upon officers that discipline cannot be attained without constant watchfulness on their part. They must attend to the smallest particulars of detail. The men must be habituated to obey or they cannot be controlled in battle, and neglect of the least important order impairs the proper influence of the officer."

Conclusions.

The attainment is a long and sometimes an uphill task. It can only be obtained by constant and unremitting effort on the part of all officers and N.C.O's. It must be taught on every possible occasion, and never allowed to relax. The developments in modern warfare have made it more necessary than it ever was. Upon the officer lies the responsibility of producing teaching and maintaining the essential qualities which go to make for a good discipline. In the interests of discipline, the entire system of training should have for its object, in addition to actual instruction, the establishment of an interest in, and liking for, his profession on the part of each soldier. In battle, discipline confers a steadfast courage and is a guarantee of the essential attention to details. It also ensures the power of executing operations by the efficient co-operaion of all ranks in their mutual confidence in each other.

Experience has shown that true military discipline—discipline, that is to say, which is equally maintained before, during, and after battle; discipline which is relaxed neither in victory nor in defeat—can only be secured by the moral power of officers deriving their authority from good law wisely administered by means of a sound system of organisation.

In conclusion, I can do no better than quote the words of the Duke of Wellington, in a letter to the Conte de la Bisbal in 1813:

"Unless we ourselves set an example of obeying strictly the orders of our superiors, we cannot expect that our inferiors will obey ours".

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AN AZIMUTH CHART.

By Lieut.-Col. R. K. Hezlet, D.S.O., *pac.*, R.A.

THE determination of the true bearing of the sun or a star from an observation of its altitude (angle of sight) requires the solution of a spherical triangle (the triangle pole—zenith—star).

In the R.A. Journal for October 1917, Major Nanson describes ("Use of Stars for Artillery Purposes") the standard method of solving the triangle with the aid of declination tables and tables of logarithmic trigonometric functions.

It occurred to the present writer that a graphic solution without the use of tables might be feasible, and the Azimuth Chart which accompanies this note has been evolved as the result of investigation.

The chart is an adaptation and development of a nomogram given in d'Ocagne's "Traité de Nomographic" for the solution of another problem in spherical trigonometry.

Since drawing the diagram the writer has been informed that a similar solution has been described in the Proceedings of the U.S. Naval Institute for November 1917, but he has not seen the paper in question.

The chart is simple and quick to use and does not require the use of any tables or logarithmic calculation. It will give the answer correct to the nearest ½ degree, and even when a greater refinement in accuracy than this is necessary it serves as a very useful check on more elaborate calculations.

Its use is best illustrated by simple examples.

(1). Latitude 50° 50′ N. Altitude of a West star α Boötis (Arcturus) is observed as 19° 59′. To find its true bearing (this is one of Major Nanson's examples).

Observed altitude	=	19°	59′
Correction for Refraction	=		−3′
h	=	19°	56′
ϕ	=	50°	50′
$\phi + h$	=	70°	46′
$\phi - h$	=	30°	54′

Join 30° 54′ on HM (see key diagram on chart) to 70° 46′ on KL. Draw a horizontal line through α Boötis on the left hand star scale (the one headed "Polar Distances for North Latitudes"), and a vertical straight line through the intersection of these two straight lines to cut the scale ML. This gives A = 83°, so that star was 83° W. of N. True Bearing of Star was therefore 277°.

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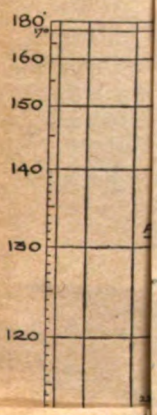

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(2). 10th April 1918. Latitude 25° S. Observed altitude of rising sun 10° 5′. To find its true bearing.

Observed altitude	=	10°	5′
Correction for refraction	=		4′
h	=	10°	1
ϕ	=	25°	
$\phi + h$	=	35°	1′
$\phi - h$	=	14°	59′

Join 14° 59′ to 35° 1′ on their respective scales. Draw a horizontal line through the 10th April on the right hand sun scale (as the Latitude is South). Draw a straight line vertically downwards through the intersection of these two straight lines to cut ML. This gives A = 103°. The sun is therefore 103° E. of S. or the true bearing is 77°.

Only a few principal stars and guiding dates have been inserted on the polar distance scales, but as the actual polar distance can be read in degrees on the extreme left hand scale, it is easy for the user to make any additions found desirable, extracting the necessary polar distances from the declination tables in the Almanack.

30.

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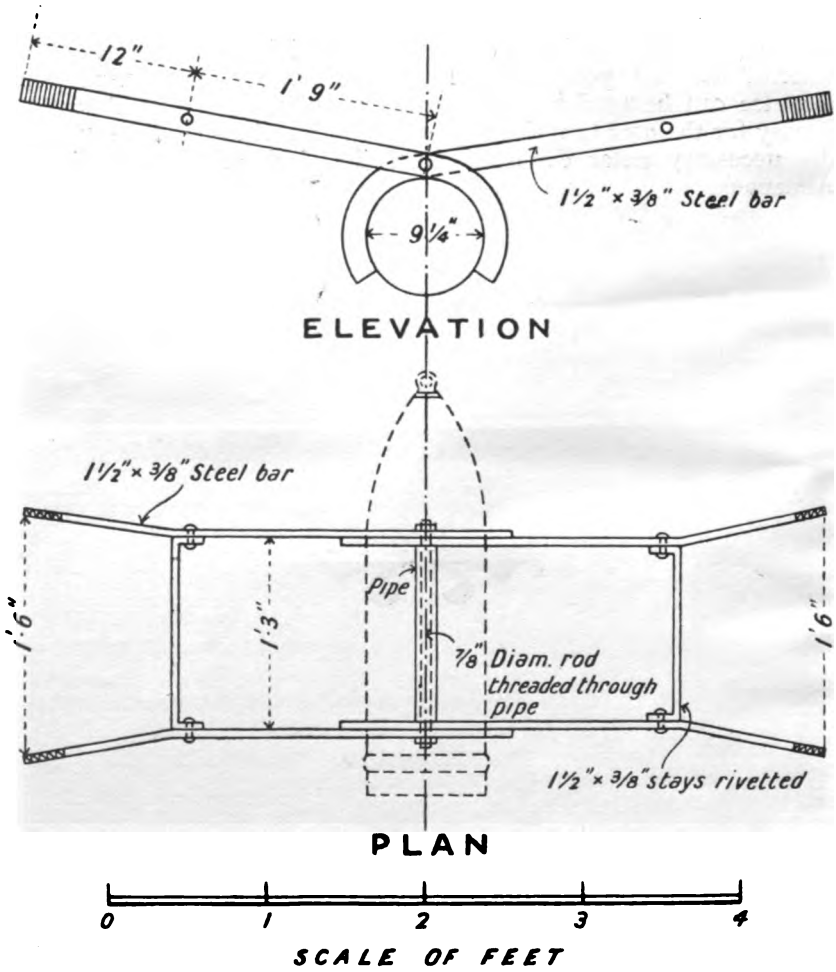
LABOUR SAVING DEVICES IN THE FIELD.

By Major F. T. Ryan, M.C., R.G.A.

NOW that the question of economy in man power is brought into such prominence it is thought that the following description of labour saving devices may be of interest to officers of the heavier natures of siege artillery.

THE "TAVY" TONGS.



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My battery was a 9·2″ Mark I Howitzer and after a few months work with the appliances supplied on the G. 1098 for moving shell, it was evident that they could be improved upon.

My ideas were put into being by my Battery Staff Sergt. A. K. Scott, Fitter-Corporal A. Chapman, and Smith-Corporal D. Hamilton. The material was "scrounged" from the debris of agricultural and other machinery, of which there is abundance in the line.

The first invention is the "Tavy" Tongs ("Tavy" was our code name) and consists of four J shaped bars connected by a hinge bolt and distance pipe, and two cross supports, and is on the principle of a fishmonger's ice hook. The handles can be fitted with wooden grips, or covered in leather. The drawing explains itself.

Its advantages are:—

(1). Requires only two men to lift when loaded.
(2). Requires only one man to lift when empty.
(3). Folds up and takes no room.
(4). Requires no special tray.
(5). Quickly applied.
(6). Shell can be gripped in any position.

The "Shell Transporter" supplied:—

(1). Requires 4 men to lift when loaded.
(2). Requires 2 men to lift when empty.
(3). Takes up a lot of room.
(4). Must have its special tray under shell or be used upside down.
(5). If at all strained, is troublesome to work.
(6). Shell must be on level ground.

The second invention is the "Tavy" Trolley—a one man trolley for transporting shell some distance over fairly good ground. It consists of a pair of low wheels 18″ or 24″ in diameter, a bent axle, a main bent shaft, and handle, with side supporting rods.

The original wheels were from the "barrows, drum, universal" but these were discarded for the iron wheels of agricultural machines as they were too whippy, and the axle was not big enough. The drawings will again explain themselves.

The iron handle can be covered with wood, shaped to fit the grip. Near the toe, a piece of curved iron should be rivetted on to keep the base of shell from rolling when going over bad ground. The axle should be not less than 1⅛″ diameter round steel, otherwise it cracks where the shaft is rivetted to it.

The axle should also be bent so that the wheels have a slight outwards play as the tendency when loaded is to bend the axle further. (See next page).

These machines were found invaluable, and I never had any accidents due to their use. I had two of each kind per gun when we were ruthlessly broken up to increase two other batteries to 6 guns. As it is no uncommon thing to receive 100 tons of ammunition at night after a heavy day's firing, any saving of labour is a saving of time, and therefore of precious sleep.

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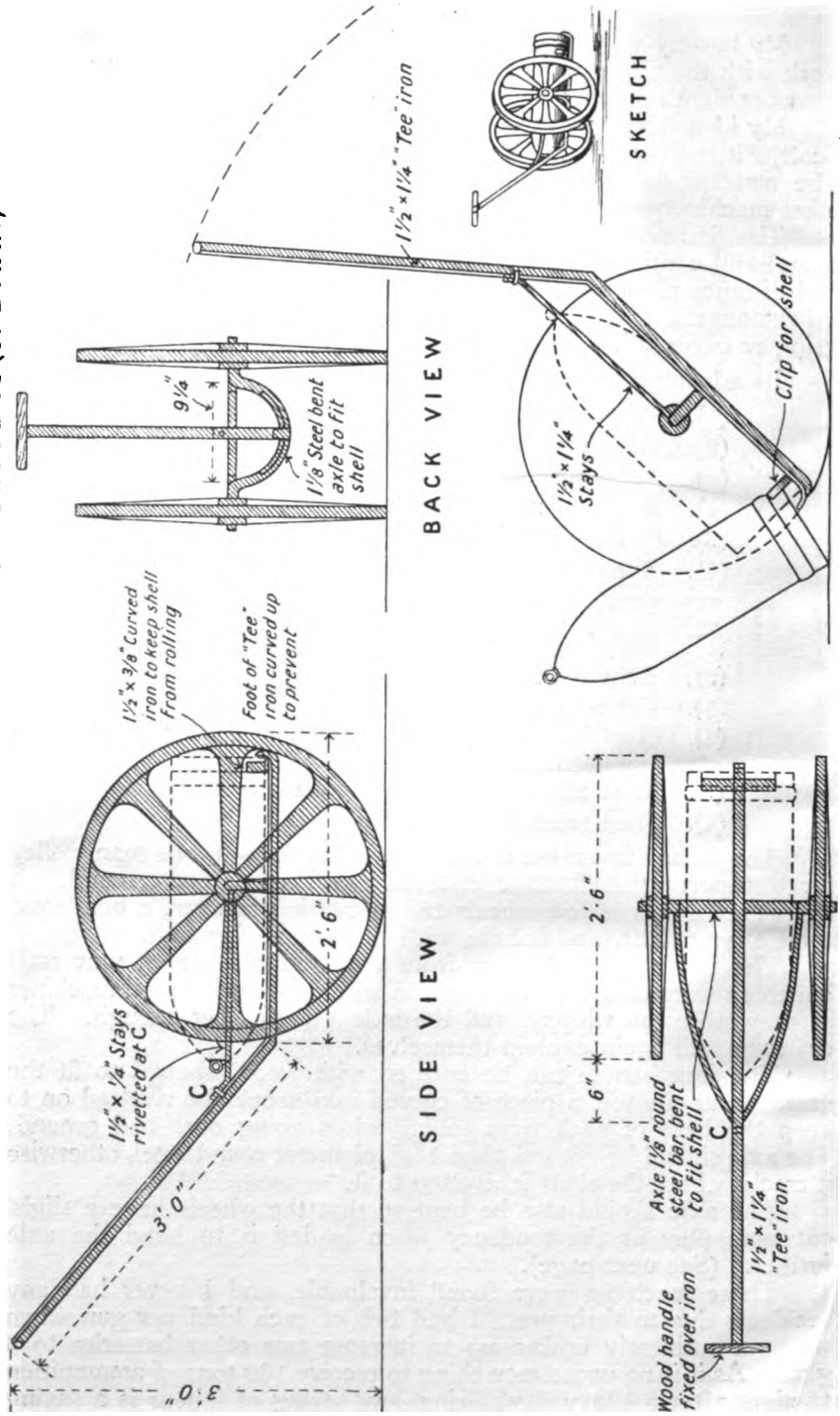

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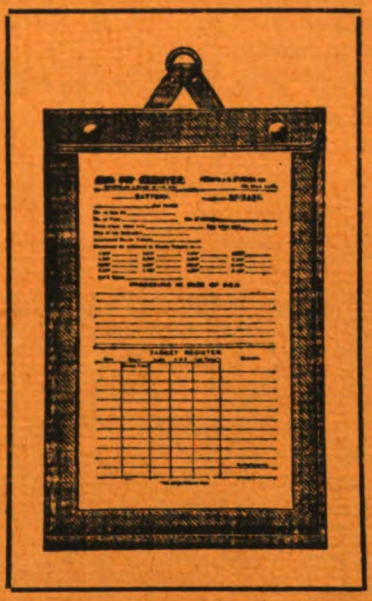

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